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COTTON SPINNING

SPINNING ROOM, TECHNICAL SCHOOL, BOLTON.

THE ELEMENTS

OF

COTTON SPINNING

BY

JOHN MORRIS & F. WILKINSON

WITH A PREFACE
BY
SIR B. A DOBSON, C.E., M.I.M.E.

CHEVALIER DE LA LÉGION D'HONNEUR

WITH NUMEROUS DIAGRAMS

LONGMANS, GREEN, AND CO.

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PREFACE

MESSRS. MORRIS and WILKINSON have asked me to write a Preface for their work on Cotton Spinning. I have been connected with these gentlemen for so long a period, and am so intimately acquainted with their capacities as authorities on the subject, that I can comply with their request in fullest confidence.

Cotton Spinning is so far removed from the exact sciences that it is not possible to subject the actual operations of manufacture to the scrutiny of a mathematical or chemical formulæ, and this natural want of exactness or inequality has to be compensated by a very apt and sometimes almost instinctive experience.

This experience can only be gained by long working practice in the mill, or by careful practical study among the machines of a technical school, and, when acquired, has to be applied in the best way.

This little book goes far to aid the practical man to use his knowledge.

The Authors have evidently considered the matters they deal with from the point of view of the anxious but unaccustomed student, and each explanation is

purposely designed to give the meaning from a common-sense rather than a purely technical standpoint.

The calculations, again, do not follow the ancient traditions, but are built on the broadest foundations of modernised arithmetic.

The student is forced to use his brains, and cannot either learn by 'rote' or by memory of 'formulæ,' but the reasoning of each step is so skilfully graded that there is no difficulty in ascending the slope.

Thus the student is taught and encouraged to 'reason,' and when in the future he may meet cases which are apparently different, a very simple analysis will show the close analogy which so often exists, though hidden. This I take to be 'Education' in its brightest and broadest sense.

I am sure the volume is a distinct addition to the few really valuable handbooks on the subject of Cotton Spinning.

BEN. ALF. DOBSON.

AUTHORS' PREFACE

———— ✦ ————

IN this work the Authors have endeavoured to give a clear and concise description of the various operations which take place in the preparing and spinning of cotton. It is to be clearly understood that the various matters found in this work are dealt with only in an elementary way. Special works dealing with particular sections of spinning are many, and for the more advanced students these should certainly be read. The Authors would here express their deep gratitude to Sir B. A. DOBSON, C.E., M.I.M.E., Chevalier de la Légion d'Honneur, France, author of many important papers on cotton-spinning subjects, for the generous use which he has allowed to be made of his own drawings, and which have made this work much more valuable than it could otherwise have been. Our thanks are also due to Mr. ABRAM FLATTERS, of Longsight, Manchester, microscopist, for the use of his copyright micro-drawings of fibres, which are found plentifully interspersed in the section dealing specially with the cotton fibre. The facts found in the chapter dealing with injurious agents have been taken from the work of the late Prof. Riley, U.S.A. Figs. 3 and 37 are from Deschamps' work, ' Études

Élémentaires sur le Coton,' a very able French treatise on the cotton fibre. We are also indebted to the work on 'The Cotton Fibre,' by Dr. BOWMAN, and to others whose names are mentioned in the work.

Mr. T. THORNLY, Spinning Master at the Bolton Technical School, has assisted us materially in the production of the work.

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JOHN MORRIS.
F. WILKINSON.

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BOLTON : *June* 1897.

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COTTON SPINNING

CHAPTER I

Cotton Wool.—The soft down or fibrous matter found in the pods of the cotton plant is the raw cotton wool of commerce, or raw cotton, as it is usually styled.

If a pod be taken and examined, the seeds nestling inside are found to be covered with fine filaments, which, being firmly attached, serve as carriers for the seeds.

The plant world provides many similar cases of these thread-like attachments to seeds, many of which are dispersed by the assistance of wind to other localities than those in which the parent plant grew.

FIG. 1.—COTTON SEED WITH FILAMENTARY ATTACHMENTS.

Botanical Classification.— In classifying, the cotton plant is placed in the order Malvaceæ (Mallows). The generic name of Gossypium is given to it. In this order cotton takes the premier place, both from its commercial importance and the great number of species. Botanists are not by any means agreed as to the exact number of the members comprising this remarkable family.

Antiquity of the Plant.—There is evidence for believing

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that the cotton plant was known in India nearly a thousand years before the Christian era. Among the earliest of the ancients to describe the growth and habits of the plant was Herodotus, who, as early as 445 B.C., wrote of a tree growing in India having wool on it like that of the sheep, and which was used by the natives for the purposes of clothing.

In Pliny's time the cotton plant was very well known. This writer gave it the same name by which it is described to-day, viz. Gossypium. He also named the uses to which this white wool was put.

Cotton-growing Areas. — Vast tracts of land are now cultivated solely for the production of cotton, especially in tropical and sub-tropical regions.

These districts lie between lines drawn 45° north and 35° south of the Equator.

The accompanying map of the World on Mercator's Projection shows at a glance the countries of the globe in which cotton is produced.

It is computed in round numbers that there are about 23,500,000 acres in the United States of America, 1,300,000 acres in Egypt, 15,500,000 acres in India now devoted to the cultivation of this important fibre. Recently South America has yielded a good supply of cotton, and there are unmistakable indications that a rapid increase of production may be looked for in this district.

In 1881 the world's consumption of cotton was given as 9,424,600 bales ; in 1886–7 this figure rose to 10,468,000 bales, and in 1895–6 it reached the astonishing total of 12,000,000 bales.

Old World Cotton Fields. INDIA.—Assam district, Bombay, Bengal, Upper and Lower Burmah, Berars, Central Provinces, Coorg, Hyderabad, Mysore, North-West Provinces, Punjab, Madras, Oudh, Rajputana, and the peninsula of Gujerat.

The greater part of the cotton produced in India comes from the district of Bombay, Berars, Hyderabad, North-West Provinces, and Madras. It is computed that no less than three-fourths of the cotton grown in India is produced in the above-named States.

In ASIA considerable quantities are grown in Turkey in Asia, Palestine, Persia, and the Isles of the Levant, but as yet what has been produced has been partially used for home consumption.

According to the latest intelligence Turkestan bids fair to produce cotton of a good quality, and in considerable quantity.

The cotton produced in China is only suitable for very low counts, and the Japanese are cultivating the plant with a view to spinning it on the spot for home use.

AFRICA.—Egypt occupies the first place, being especially rich in its alluvial soils and having a suitable climate. Large quantities of cotton are produced in this country. The most important districts are Messifieh, Ziftah, Behara, Mansurah, and Zagazig.

Upper Guinea has been producing for some time a cotton of fair quality known as Lagos Cotton.

A good fibred cotton is grown in Natal in districts lying along the south-eastern coasts.

New World Cotton Fields. AMERICA.—Cotton cultivation is largely carried on in the United States, Central America, the West Indies, and South America.

The following States may be given as the most important in the United States :—

Alabama	Georgia
Arkansas	Louisiana
N. Carolina	Mississippi
S. Carolina	Tennessee
Florida	Texas.

In the West Indian Islands, Jamaica, Cuba, and Hayti are the chief.

On many of the Bahama Islands cotton of a good quality is produced.

South America yields important supplies, and the chief centres are Pernambuco, in Brazil, parts of Peru, Maceio, in Brazil, S.E. Brazil, Maranaháo, Ceara, and San Salvador.

In addition to the districts and regions named the following may be mentioned : Queensland, Fiji Islands, Society Islands, and the Marquesas Islands.

In the three last-named groups of islands a long-stapled and good-quality cotton is successfully grown.

Varieties of Cotton.—Among the older botanists much confusion existed with regard to the proper classification of the species of Gossypium growing in different parts of the world.

Linnæus computed but five species, Lamarck as many as eight, De Candolle thirteen, while Rohr names as many as thirty-four species.

Modern investigation has considerably reduced this last number, and according to Dr. Royle, in his 'Culture of Cotton in India,' all species may be classified into four great divisions, viz :—

> Gossypium arboreum (the tree cotton)
> Gossypium barbadense
> Gossypium indicum
> Gossypium peruvianum.

In the classification of cotton by Parlatore we find seven species named :—

> Gossypium hirsutum
> Gossypium herbaceum
> Gossypium tahitense

> Gossypium sandwichense
> Gossypium religiosum
> Gossypium arboreum
> Gossypium barbadense.

For all practical purposes, however, the principal types may be classified as follows :—

> Gossypium arboreum
> Gossypium barbadense
> Gossypium herbaceum
> Gossypium hirsutum.

GOSSYPIUM ARBOREUM (Latin, *arbor*, a tree).—This species is so called because of its tree-like proportions. It varies in height from twelve to twenty feet. When in bloom the plant possesses brownish red flowers, and these, together with the hairy character of its upper parts, the green covering of its seed case, the difficulty with which the filaments are removed from the seeds, and the unmistakable beauty of its palmate leaves, mark this species as one of some importance. Its native soil is found in India, Egypt, Ceylon, Arabia, and China.

GOSSYPIUM BARBADENSE.—This species is so called from the word Barbadoes, which is the name of one of the West Indian islands. This was the original home of the plant. The inhabitants of the East Indies designate it Bourbon cotton.

In growth it is distinctly shrubby. The height of the plant has been variously estimated, but it may be taken as seven or eight feet.

Speaking commercially, the Barbadense cotton is very valuable and important. The long silky cottons known as Sea Islands, the Egyptian variety known as Gallini cotton, and that grown in the littoral districts of Georgia and Florida, all belong to this particular species. It may be said, in fact, that all the American varieties belong to this species or to the Hirsutum

FIG. 2.—COTTON PLANT (*Gossypium barbadense*), SHOWING FLOWER, BOLL, MOTH AND CATERPILLAR ATTACKING PLANT. (After Deschamps.)

type. In consequence of the hardy nature of the seeds, which are black, this species has been widely cultivated, and the areas in which this plant is now grown are consequently widely distributed over the globe. It should be stated also that the distinguishing and prevailing colour of the flowers is yellow. The following countries yield supplies of this class of cotton : Southern United States, Egypt, Australia, Bahamas, and the isles of the Pacific Ocean.

GOSSYPIUM HERBACEUM.—No other species of cotton plant has so wide a geographical range as the herbaceous type. This arises from the fact that no other kind is so hardy.

It may be said, generally speaking, that the cottons produced in the Old World are of this species. Arabia, India, China, Turkey in Asia, and Egypt are the countries in which it is grown, and of which it is a native.

The celebrated Surat cotton is the product of this plant. Great care is needed in the removal of the fibres from the seeds. This process is rendered very difficult by the peculiar growth of soft short down which covers the seed in addition to the cotton fibre. The cotton suffers if, in the ginning process, it should happen that the down referred to has been carried away with the longer-fibred cotton from the same seed.

Being an annual plant, fresh shoots must be planted each year. As the name implies, this particular type does not grow to a great height, being herbaceous in nature. Its average height is about five feet. The fibre is of moderate length and the flower is yellow.

GOSSYPIUM HIRSUTUM.—This has been so named because of the generally hairy character of the plant. Not only are the seeds covered with short, green, downy hairs in addition to the fibres, but we find pods, boughs, and leaves are all more or less covered with fine short hairs.

Mexico is said to be the original home of this species.

It is peculiarly fitted for growing on lands removed from the sea, and on the uplands of the United States. From this fact we have a class of cotton known by the name of Uplands cotton. The greater portion of the cotton plants cultivated in the States belongs to the Hirsutum variety.

Other Species of Cotton.—Gossypium peruvianum, as the name implies, is a native of Peru, and is of some importance. It is obtained from most of the South American States devoted to the growth of cotton. Among these we may name Brazil and Peru. 'The Tree Cotton of Brazil,' according to Shepperton, 'is also known by the name of Maranaháo cotton, and attains a height of fifteen feet to twenty feet, and will yield well for two or three years. It produces a better quality of cotton than the herbaceous varieties grown in Brazil, and, while the yield is smaller, it suffers but little from caterpillars, which are very destructive to other kinds. The bolls are large, containing seventeen seeds.' The ripe cotton in the case of this plant does not protrude from the bolls.

CHAPTER II

Cultivation of American Cotton.—Nearly the whole of the cotton crop of North America is produced between the 29th and 37th parallels of north latitude, and between the 67th and 100th meridians of west longitude.

The supply of moisture for the *rainfall* over the cotton States is derived almost entirely from the Gulf of Mexico. The rainfall varies in amount from twenty-eight to sixty-four inches, although over the greater part of the cotton-growing area it only varies between forty and sixty inches. The rainfall is greatest over the Mississippi delta and vicinity, while in the cotton-growing portion of Texas the rainfall is much less, varying between twenty-eight and forty-four inches.

The average precipitation during the months of June, July, and August in the delta portion of the Mississippi, Louisiana, Arkansas, Tennessee, and Alabama in 1896 was 10 inches. North and South Carolina, Florida, and Georgia show similar conditions. It has been noted by Professor E. A. Smith that those cotton-growing districts where the percentage of area under cotton cultivation reaches ten or more, have a summer rainfall below fourteen inches and a winter rainfall above twelve inches.

As regards *temperature*, the mean in the American cotton-growing States usually varies from 81° F. in July and August to 75° in May and June ; while in winter it is often below zero.

Since the emancipation of the Negro slaves there has been a tendency for cotton to be cultivated on a comparatively

small scale by local farmers, though there are still larger plantations in America than elsewhere, and therefore the crops are raised under more uniform conditions. The method of planting differs from that which obtains in some countries. The method adopted is to have rows of cotton plants about five feet apart. In every row the seeds are placed in holes about a foot and a half apart, several seeds being placed in each hole.

As is the case with some other plants, when the young ones begin to come up, the weaker of them are weeded out and the stronger plants lopped. They then begin to branch freely. We thus get picked seed to begin with, and, in addition, any poor plants are at once cast out. The seeds may be planted in March, April, or May, and the plants begin to bloom in June and July. The cotton is picked chiefly during September ; the earlier descriptions in August and the later sorts in October. The total value of one full crop of American cotton, including Sea Islands, has been estimated to reach about £60,000,000; but this, of course, varies with the success of the season and the prices ruling.

Brazilian and Peruvian.—Ranking third in quality and fourth in quantity, the cultivation of cotton in Central and South America is carried on to a comparatively large extent. 'Santos,' which began to be cultivated during the American Civil War from American seed, does not seem to have received much development.

In Peru, the best district is in close proximity to the high table-lands, owing to the mildness and regularity of the climate. In Brazil, although only a comparatively small proportion of the land is utilised, there is an abundant area of suitable country. The plantations are usually small, and picking, ginning, and baling are often inefficiently performed. It is well known that yarns spun from Brazil cottons have a harsh and brittle structure as compared with American or Egyptian, although in price

and general quality they come between these two, and are much used by hosiery manufacturers.

Cultivation of Cotton in Egypt.—A little over fifty years ago the cotton plant was introduced into Egypt. Of recent years the Egyptian crop has annually been on the increase. During the season 1895–96 no less than 680,000 bales were exported from Egypt. Only seven years ago 908,000 acres were devoted to the cultivation of the plant. The returns for last year show that 1,300,000 acres were sown with cotton plant, giving the yield named above. In many parts of the country rude and primitive methods of cultivation still obtain. With modern improvements there is reason for believing that double or treble the quantity could easily be produced.

Almost total dependence is placed upon the periodic overflows of the Nile, which occur annually about the month of September, leaving a deposit of rich silty matter. In this the seeds are sown. As the deposit is far from uniform in quantity and quality, it follows that there must be considerable variation in the nature of the crop produced. Then, again, the selection of seed does not receive that attention which it ought to have if first-rate crops are to be obtained. Generally speaking, however, the Egyptian cottons stand very high in the estimation of the commercial world ; but there is no reason why, with care and proper management, this class of cotton should not be considerably improved.

A notable feature possessed by the Egyptian cottons is that they are deeper in colour than those of other countries, being of a deep golden yellow. In consequence of this, mixing with the cottons of other countries is prevented to a great extent.

In some parts of the country artificial watering is carried on, but never so successfully as when land is irrigated by the Nile. In consequence of fogs which prevail at the end of autumn and do damage to the crops, it is found desirable to

collect and gin the cotton as early as possible after maturity has been reached.

The *yield per acre* in Egypt is exceptionally good when compared with that of other countries. For example, the yield on the average for the United States is about 300 lbs. per acre. In India it is considerably less than 100 lbs. per acre, while in Egypt it is generally over 300 lbs., and has been as high as 500 lbs. per acre.

Cultivation of Cotton in India.—The quality of the cottons produced in India is of a poorer type than those produced either in America or Egypt.

The average length of the fibre is shorter and the average diameter is thicker. Its value, however, as a commercial article is high. India as a cotton-growing country dates from the time of the American War. Supplies failing from the States, India was requisitioned. The call was answered, and ever since it has continued to send to other countries vast quantities of cotton suitable for low counts. No other country in the world produces so much as India, with the exception of the United States.

As we glance over a map of India showing positions of cotton fields we find that the cotton-growing areas lie in the following districts : Bombay Province, the peninsula of Gujerat, the district of Scinde, the Punjab, and a portion of the Central Provinces.

The method of cultivating the plant differs very considerably in India from that which obtains in the United States. Chisholm says : ' The period of the year during which cotton is grown is the same as in the States, since it is dependent on the rains of the south-west monsoon. But in the region of India where cotton is principally grown on a large scale for export—a region lying mainly on the peninsular plateau behind the Western Gháts, which drain the rain clouds of most of their

Fig. 3. Map showing cotton producing countries coloured red. Thick red lines of latitude show Northern and Southern limits.
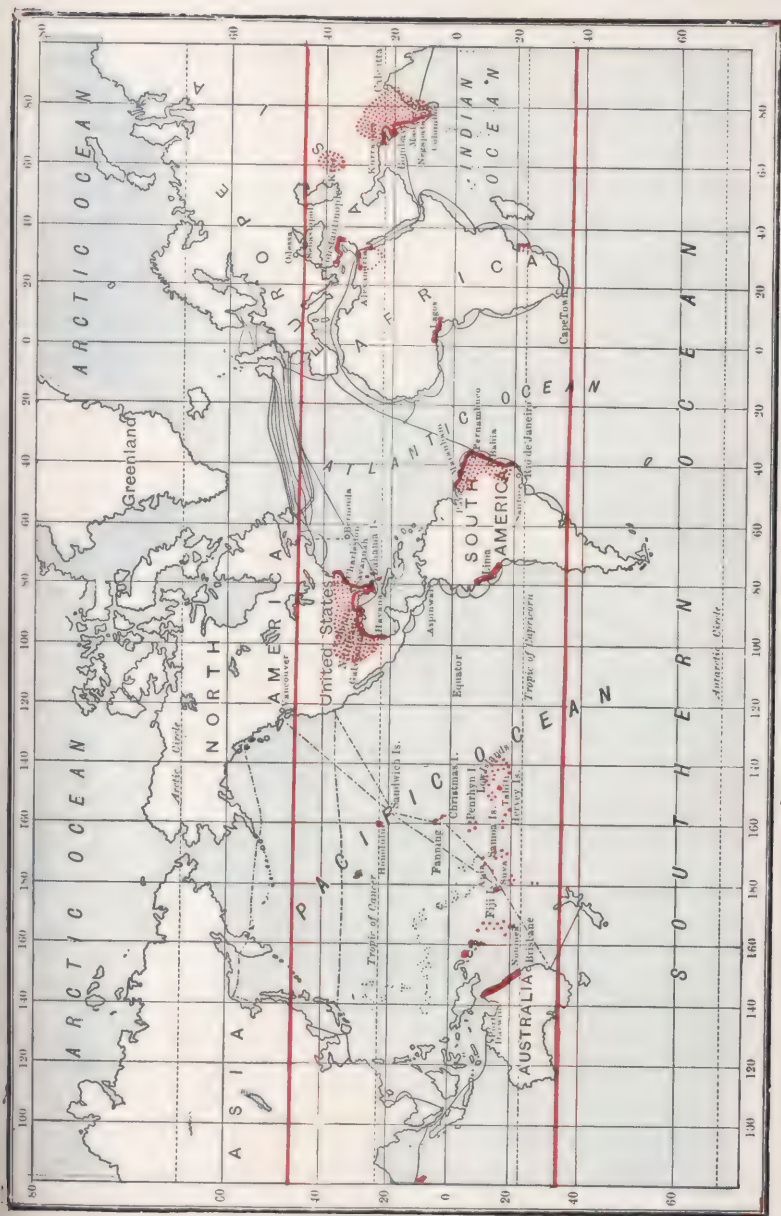
Longmans Green & Co. London, New York & Bombay

moisture—the total rainfall is comparatively scanty, seldom more than thirty inches during the period when the cotton is grown. Beyond this region cotton is grown in extra-tropical India, chiefly in the North-West Provinces and in the Punjab, where the rainfall is even scantier, but where there are extensive areas under irrigation.' Great preparations are made with the land before the rain falls, and consequently the greater part of the lands devoted to cotton growing are sown with seed before the setting in of the monsoons.

The following table shows at a glance the chief districts of India, the ordinary time for preparation of land, date of planting, and date of picking :—

District	Preparation	Planting	Picking	
			Begins	Ends
Madras .	Sept. and Oct.	Oct. and Nov.	April . .	June
Broach .	May ,, June	June	Nov. . .	Jan.
Bengal .	,, ,, ,,	,,	Oct. . .	Dec.
Oomrawuttee	,, ,, ,,	,,	Nov. . .	Jan.
Dhollerah .	,, ,, ,,	July	Feb. . .	April
Dharwar .	August	August	Feb. . .	May

It must be remembered that in India there are two monsoons or rain-bearing winds. In the table it is seen that in the Madras Presidency the sowing and preparing are done in September, October, and as late as November. This is explained by the fact that in this district the north-east monsoon prevails, and sowing is done just prior to the setting in of this wind, which occurs about the autumnal equinox.

The soil of India, generally speaking, may be said to be exceedingly rich in mineral matter and eminently suited to the growth of cotton. The black cotton soils of India have long been famous as suitable to vegetable growth, and this accounts for the fact that little or no artificial manure is used by the cotton planters. They are exceedingly rich in that necessary ingredient

carbonate of lime, and nodules containing a large percentage of lime abound throughout the soils of India.

Unlike the American methods, the seeds are not sown in rows, but broadcast. This is considered advisable. As little evaporation is desired, the crowding together of the plants has this effect.

Agricultural operations are exceedingly simple and primitive.

CHAPTER III

Agents Injurious to the Cotton Plant.—The following agencies are injurious to the cotton plant, especially in its earlier stages :—

1. Extremes of heat and cold.
2. Abnormally wet and dry seasons.
3. Insects.

It appears, from observations extending over many years, that the young shoot is unable to stand the heat of the sun unless there be in the soil a sufficient quantity of moisture to enable the plant to cope with the evaporation. In the returns for the season 1880–1 the number of bales produced in the United States of America is recorded as 6,606,000. In the following year the number fell down to 5,456,000 bales, a difference of 1,150,000. This decrease was due to the havoc played with the crops by the abnormally high temperatures which prevailed in the early season of the plant's growth. Then, again, frosts do great harm, especially during the growing period. There are times, however, when a frost is a positive good. If the plant has been making tissue too quickly this is checked by a frost, and the opening of the pods often accelerated in consequence. As a rule, by the end of March frosts have disappeared, and thenceforward to autumn little is to be feared in this respect. From a record published by the weather bureau of Washington, U.S.A., the dates of frost appearance vary in the different States.

In the season 1891-2 North Carolina (Charlotte) had the early killing frosts of autumn on October 20 ; Atlanta, in Georgia, on the same date ; Florida, November 18 ; Louisiana, November 30 ; Arkansas (Little Rock), October 23 ; and Memphis, in Tennessee, October 23.

About seven months usually intervene between the last frosts of spring and the first frosts of autumn. It is obvious that the longer the period is between these two points the better must it be for the plant.

Rains, if too long continued, do much harm to the crop. The young plant requires for its proper nourishment a good supply of water, especially in April and May. It follows that if the rains are prolonged into summer much injury will result, and the crop falls an easy prey to insect life. Given a good supply of water and an equable distribution of heat, a heavy crop may be anticipated.

It happens, however, sometimes, that too much rain prevents the collecting of the mature fibre. This was the case in the season of 1880, when over half a million bales were left in the fields ruined.

Insects Injurious to Cotton.—From reliable statistics collected by Professor Riley and published by the United States Entomological Commission, there cannot be the slightest doubt that irreparable damage is annually done to the crops by insects.

The following table, on page 17, taken from the source just noted, shows the amount of loss in bales and English money in a year of severe visitation.

It appears, according to the table, that the rate of increase of loss travels in a westerly direction. The countries, too, situated in more temperate regions do not appear to be affected much by the pest, as they show only losses of from 5 to 8 per cent.

State	Percentage Loss	Crop. Average No. of bales 14 years	Loss. Average No. of bales for worst year	Loss in Pounds, at £10 per bale
Florida . . .	24	49,700	12,000	120,000
Georgia . . .	16·5	474,600	78,422	784,220
Alabama . . .	17·8	536,700	95,790	957,900
Mississippi . .	17	706,000	123,070	1,230,700
Louisiana . .	20	438,700	89,740	897,400
Texas . . .	28	525,000	148,125	1,481,250
S. Carolina . .	5	224,500	11,225	112,250
Tennessee . .	5	147,000	8,365	83,650
Arkansas . .	8	347,000	27,760	277,600
	17·2 average			

THE COTTON CATERPILLAR (*Alethia argillacea*).—Order Lepidoptera (scale-winged, as moths and butterflies) ; Family Heterocera (antennæ variable) ; Class Noctuidae (night flyers) ; Genus Alethia.

Without doubt this insect occupies the chief position as an injurious agent to the cotton plant, on account of its wide distribution and voracious and destructive habits.

Like all others of the moth tribe, it passes through the four great changes in its lifetime, viz. : the egg ; the caterpillar, or larva ; the pupa, or chrysalis ; and the moth, or imago.
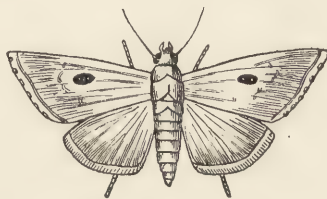

FIG. 4. – COTTON MOTH (*Alethia argillacea*). After Riley.

The eggs are very small in size, being $\frac{3}{5}$ of a millimetre in diameter. An ordinary pin head may be taken as being something near the measurement just given. They are exceedingly beautiful, and, viewed on the flat side, they appear to be marked by a number of concentric circles, just like what we see in the

section of the trunk of an oak tree. Fig. 5 gives an enlarged view
of an egg in two positions. Extremes of heat and cold prevent
the development of the egg. In seeking a place on which to
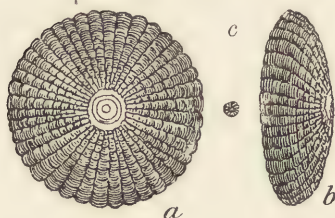deposit its eggs the moth generally decides upon the larger of
the lower leaves of the plant,
and the under side of those
leaves ; *see* fig. 3.   The eggs
are somewhat difficult to find,
owing to their having a pro-
tective colouring similar to
that of the leaf. This mimicry
of nature is one of the scien-
tific puzzles now being studied
in particular by students of
natural history.   A moist

FIG. 5.—EGG OF COTTON CATERPILLAR.
a and *b*, enlarged views ; *c* natural size.
(After Riley.)

atmosphere undoubtedly assists the hatching of the eggs, while
a dry high temperature acts as a deterrent.   The moth places its
eggs singly as a rule, and in order to give every advantage to the
development of the larva it does not lay more than three or
four eggs upon the same leaf.   Under ordinary circumstances
the caterpillar emerges from its shell in three or four days, being
only one-twelfth of an inch in length.   In the early spring and
late autumn a little longer time elapses in the production of
the caterpillar.   While existing as larvae no less than five moults
take place, and not until after the second do they leave the
under side of the leaf.   After this, and before the fourth moult,
they have made their way to the tenderer leaves which lie at
the top of the plant, leaving the harder and more indigestible
tissue until later.

   The caterpillar when full grown is $1\frac{7}{16}''$ in length and
is wonderfully adapted for rapid travelling.   Its power of spin-
ning a thread is of great utility.   If descent is desired, a thread
is spun.   This is attached readily to leaf, twig, or branch.

Thus fastened, and gliding down, the animal feeds in pastures new. *See* fig. 6, *a* being side view, and *b* dorsal view.

It also possesses the power of jumping or springing, and cases have been known where jumps exceeding two feet have been performed.

The length of time which elapses between the deposition of the egg and the appearance of the chrysalis varies from one to three weeks, according to the moisture of the atmosphere and the temperature. The average period is fifteen days.

Distribution of Alethia.—From careful observation it appears that the Alethia is confined entirely to the American continent and the islands lying in close proximity. Specimens of this species have been found as far north as Quebec, and the most southern point of its distribution is, as far as is known, S. Paulo, a southern province of Brazil. Of course the countries of the Old

FIG. 6.—TWO VIEWS OF COTTON CATERPILLAR. Enlarged.

a, gives side view, and *b* dorsal or back view. (After Riley.)

World devoted to the production of the cotton plant have their insect pests, but these are other than the Alethia.

The Boll Caterpillar, which does great damage, is also found in the States. India, too, has its injurious caterpillars. These attack the boll particularly, and do great harm by preventing the proper development of the fibre. Greece, Egypt, and Australia all likewise suffer in

FIG. 7. — CHRYSALIS OF COTTON MOTH. (After Riley.)

this respect. The latter country is the home of a species of

C 2

hemipterous insect known as the red bug, or cotton stainer (*Dysdercus suturellus*). This insect is found in the West Indies also.

Number of generations produced annually by Alethia.—So long as the conditions are favourable the Alethia continues ovipositing. The popular impression, however, is that only three broods are produced by this moth in the year. This has been proved erroneous by Prof. Riley, who, by removing the plant and moth away from frost, succeeded in keeping the moth depositing its eggs until December, in the city of Washington. Writing on this subject, Shepperton says : ' The first generation appears about May 1, in the extreme south. In southern Texas as many as seven generations are produced in the season. The first and second generations are confined to restricted areas, often not exceeding a few acres.'

' The third generation becomes more widespread, and the moths produced from it so numerous that they begin to migrate. This generation appears in southern Texas in the latter part of June, and in South Alabama and Georgia somewhat later.'

' This is usually called the "first brood" in those sections, but it is simply the first which has attracted notice. The subsequent generations become, under favouring conditions, more and more numerous, widespread, and destructive. In the northern portion of the cotton belt the number of broods is fewer, and varies according to the date of the first appearance of the moth from further south, and other circumstances.'

' There is increasing activity in development until July, and thereafter decreasing. In midsummer from the laying of the egg to the development of the moth takes but three weeks, while earlier and later in the season it may take twice as long. The average time from the egg of one generation to that of another is about a month. The caterpillar is seldom noticed, and never in great numbers, until the plant begins to bloom.'

Being nocturnal, the moth as a rule only flies by night,

though if it be disturbed in the day it rises and continues on the wing, shortly afterwards alighting again to rest.

When two or three broods have been deposited in one locality the moths commence migrating to other fields, and continue ovipositing until the end of the season.

The hibernating of moths, or power of living through the winter, has been an interesting subject to American entomologists especially. The greatest difficulty has been experienced in teaching the farm hands that the eggs are not rained down or spring up from the earth, but that they are deposited by those moths that have succeeded in living through the winter, and have experienced none of the chilling frosts which would certainly have exterminated them.

It is clear that areas subject to extremes of cold in winter will not be the places selected by the Alethia for hibernating. From reliable reports it appears that the States in which the moth winters are those lying in the south-west.

It is stated also that mild winters and those which from some cause or other have occasional periods of warm weather in them do not favour the spread of Alethia. This arises from the fact that on the approach of warmer conditions the eggs are hatched and the caterpillars developed, but as this state is arrived at before the growth of the plant they die for want of food, and all further danger, so far as they are concerned, is averted.

Very peculiar places are selected by the moths for the purpose of hibernating. Among these may be mentioned the following : niches, cracks in old walls, window frame corners, rafters and beams of workshops and ginning rooms, beneath tree bark, among the roofing timber of houses, among the thick grass of the cotton fields and their immediate neighbourhood, and especially among decaying and decayed timber.

EXTIRPATION OF COTTON CATERPILLAR. *Natural agents.*— Many difficulties are presented in dealing with the destruction

of the Alethia in any one of the four stages which have been named. The eggs are not easily seen, and any method adopted for the collection and subsequent destruction must be long, tedious, and unsatisfactory.

The caterpillars are difficult to deal with, but of the four stages this has been found from experience to be the best for suppressing the pest. The pupa and moth give also considerable trouble for several reasons. Among the natural agents which materially assist man in his efforts to put down the ravages of the Alethia are the following animals : hogs, racoon, skunk, opossum, and bats.

Birds, too, perform considerable service in destroying myriads of young caterpillars as they feed upon the plants. Among these may be named the following : turkeys, chickens, guinea fowls, geese, quails, and hawks.

Spiders, wasps, and ants also do much to assist man in his attempts to exterminate the cotton caterpillar. Writing on this subject, Professor Riley says :

' Careful observation in the fields for a single season will convince anyone that these natural enemies are far more numerous than has hitherto been supposed, and that without their aid man would be powerless to cope with an insect with such powers of multiplication as the Alethia possesses.'

Artificial agents.—It would be a difficult matter to enumerate all the methods which have been tried to put down the growth of the cotton caterpillar.

Among the most successful of the efforts must be mentioned that of sprinkling powdered poisons on the plants. That most commonly used is Paris Green. Arsenic and red lead are sometimes used. Another method of applying the poison is that of dissolving the powder and afterwards spraying the plant. Many inventions have recently been put in the market in the form of sprays for this special work.

CHAPTER IV

Cotton for Twist and Weft Yarns.—The following properties are considered in classifying cottons for the purposes of twist and weft yarns :—

For twist	For weft
1. Length of fibre.	1. Softness.
2. Strength of fibre.	2. Length of fibre.
	3. Strength of fibre.

Cottons of good length are universally preferred for the purpose of yarn for twist, for the following reason :—

As a rule, twist yarns are of higher counts than weft yarns. The higher the counts the greater the necessity for long, fine, and uniformly even-fibred cotton. More is said of this in another place.

Generally speaking, the strongest cottons are used for twist yarns.

Weft yarns are considered good when made from fibre of proper length and strength coupled with a soft oozy nature, which in weft yarns is particularly desired.

Figures 8 and 9 show the chief types, forty in number, of cottons enumerated in the tables given on pages 24 and 25. It should be remembered that the illustrations are drawn to a scale of $\frac{1}{8}$th.

TABLE OF CHIEF TYPES OF COTTONS

(Arranged in order of commercial value)

Commercial name	Average length in inches	Average diameter in inches	Yarns suitable for	Most important characteristics
(1) AMERICAN COTTONS				
Orleans .	1·08	$\frac{1}{1320}$	30's to 55's twist and weft	The best of these cottons, Benders and Peelers, are special qualities of Orleans which can be used for still higher counts. Fibres are strong, soft, moist, and of a light creamy colour.
Texas .	1·0	$\frac{1}{1310}$	30's to 50's ,, ,,	Very similar to one above, but somewhat inferior and of a deeper colour.
Uplands .	·98	,,	Up to about 40's weft	Weaker and shorter than Orleans.
Mobile .	·95	,,	Up to about 34's weft	Neither as clean nor as strong as preceding cottons.

NOTE.—American cottons form much more than one half the total produce of the world. They have about one inch average length of staple, taking all the growths.

Commercial name	Average length in inches	Average diameter in inches	Yarns suitable for	Most important characteristics
(2) INDIAN COTTONS				
Hingunghat .	1·04	$\frac{1}{1200}$	Up to 28's twist	This is the best of Indian cottons, strong fibre, of a light golden tint.
Broach .	·90	,,	Up to 26's weft	Deep-coloured, moderately clean, and well cultivated.
Oomras .	·90	,,	For lower numbers than Broach, both weft and twist	Somewhat dirty, but moderately regular and strong.
Dhollerah .	·90	,,	Up to 20's twist or weft	Dull white. Dirty and moderately strong.
Tinnevelly .	·90	,,	Up to 24's twist	In good demand. Dull cream colour, moderately clean.
Dharwar .	·80	,,	Below 20's twist or weft	Creamy colour, irregular fibres. Gin cut often.
Madras .	·80	$\frac{1}{1180}$	Up to 18's twist	Dirty, but moderately strong.
Comptah .	·80	,,	Up to 18's weft	Dirty and weak.
Bengal .	·80	,,	Up to 15's twist	Strong, harsh, dirty.
Scinde .	·75	,,	Up to 12's twist or weft	Dull white tint, moderately clean, short and weak.

(3) EGYPTIAN COTTONS

Name				Description
Gallini .	1·5	$\frac{1}{1500}$	Up to 200's	Strong, fine, light golden colour, not very much cultivated.
Brown .	1·4	$\frac{1}{1480}$	Used for from 30's to 120's	This forms the great bulk of Egyptian cottons. Of a golden colour, not much mixed with other cottons.
White .	1·2	$\frac{1}{1400}$	Up to 70's	Mostly consumed abroad. Not largely cultivated; sometimes mixed with South American.

(4) BRAZILIAN COTTONS

| Name				Description
Pernams .	1·3	$\frac{1}{1260}$	As high as 70's	These cottons are all more or less characterised by a harsh, wiry feel. They give an oozy character to the yarn, and are much used for hosiery purposes. Pernams is the best, and the others do not differ much in quality, although they vary somewhat in colour. Santos is grown in Brazil from American seed, and is softer than other Brazilian cottons.
Maranhams .	1·2	,,	Up to 60's	
Paraiba .	1·15	,,	,,	
Ceara .	,,	,,	,,	
Maceio .	,,	,,	,,	
Bahia .	,,	,,	,,	
Aracati .	,,	,,	,,	

(5) SEA ISLANDS COTTONS

| Name				Description
Sea Islands .	1·8	$\frac{1}{1576}$	From 80's to 350's twist or weft	The finest cotton grown. Has been spun up to 2000's. Only used for the best yarns. Always combed. Noted for regularity of twist and diameter.
Florida Sea Islands .	1·65	,,	Up to 200's twist or weft	Somewhat inferior to preceding cotton, otherwise much similar in chief features.
Fiji Sea Islands	1·75	,,	Up to about 200's twist or weft	Not as regular as two preceding varieties.
Peruvian .	1·5	$\frac{1}{1500}$	Up to about 120's twist or weft	Inferior to all preceding varieties.
Tahiti .	1·4	,,	,,	,, ,,

(6) SOME LESS IMPORTANT VARIETIES

Name				Description
Peruvian rough	1·25	$\frac{1}{1300}$	30's to 70's twist or weft	Harsh, wiry, clean, and makes good hosiery yarn.
,, smooth	1·25	,,	,, ,, ,,	Soft, smooth, and pliable.
West Indian .	1·1	,,	Up to 46's twist or weft	Irregular in staple and colour.
African .	1·0	$\frac{1}{1200}$	Up to 30's twist or weft	Badly cultivated, some samples almost like waste.
Smyrna .	1·2	$\frac{1}{1300}$	Up to 44's twist or weft	Dull white colour, harsh, irregular in twist.
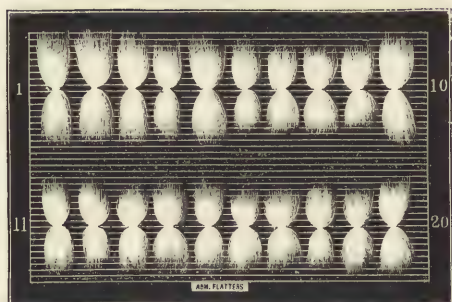
FIG. 8.—COMPARATIVE LENGTHS OF COTTONS. Scale ½th.

1. Sea Islands, extra fine ; 2. Georgia ; 3. Florida ; 4. Tahiti ; 5. Gallini ; 6. Brown Egyptian ; 7. White Egyptian ; 8. Ashmouni ; 9. Smyrna ; 10. Peruvian Smooth ; 11. Rough ; 12. Rios ; 13. Ceara ; 14. Maceio ; 15. Pernam ; 16. Maranhams ; 17. Paraiba ; 18. Peruvian Red ; 19. Allan seed ; 20. Peelers. (After Flatters.)
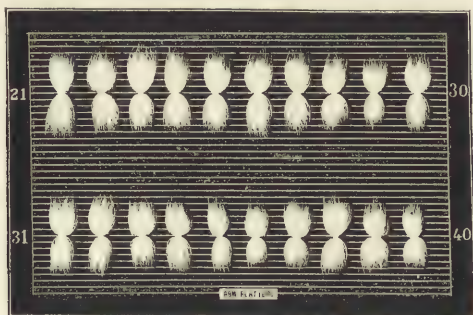
FIG. 9.—COMPARATIVE LENGTHS OF COTTONS. Scale ½th.

21. Benders ; 22. Nashville ; 23. Orleans ; 24. Memphis ; 25. U. S. Ordinary ; 26. Uplands ; 27. Texas ; 28. Hingunghat ; 29. Oomrawuttee ; 30. Broach ; 31. Rangoon ; 32. Tinnevelly ; 33. Dharwar ; 34. Comptah ; 35. Dhollerah ; 36. Scinde ; 37. China ; 38. Lagos ; 39. Bengal ; 40. Assam. (After Flatters.)

CHIEF COMMERCIAL TYPES OF COTTON FIBRES

Sea Islands.—This expression is used when speaking of the best classes of cotton grown in the United States of America. It is a significant fact that the longest-fibred and most highly

prized varieties are grown on the coasts of Florida and Georgia, and on the neighbouring islands, Edisto being the best. Hence the name 'Sea Islands.'

The average length of fibre of this class of cotton is nearly $2''$. It is even in structure, having an average diameter of $\frac{1}{1570}''$. When examined by the microscope the con-

volutions or natural twists are very regular. There is, however, much unripe fibre among this class, and this appears in the form of flat ribbon-like threads, having no twist in them, and looking very much like flattened tubes. Sea Islands cotton is silky in nature, fairly strong, and suitable for the very highest of counts. All the Sea Islands varieties belong to the species 'Barbadense.'

Fig. 10 gives a comparative view of sections of Sea Islands extra fine, Tahiti, Florida, and Georgia.

Fig. 10.—Sea Islands in Section. Scale $\frac{1}{1000}'' \times 280$ diameters.

1. Extra fine ; 2. Tahiti ; 3. Florida ; 4. Georgia. (Flatters.)

They are drawn to a scale of $\frac{1}{1000}''$ and magnified 280 times.

It will be seen from what has been said before that the majority of the sections shown are those of ripe specimens, forming perfectly developed tubes. The central canal is very noticeable in nearly all the types.

Fig. 11 shows the fibre longitudinally under a power of over 300 amplifications.

Sea Islands, Tahiti.—This variety belongs to the Barbadense species, and is a very fine cotton. The fibre is extremely long, but not equal to the Sea Islands proper. It is fine and silky, very neppy, and liable to nep in its working. When it can be got clean it is considered suitable for very fine weft.

A noticeable feature in the specimens examined is the variation in the thickness of the tubes ; *see* fig. 12. The

diameter of the fibre is much the same as the Sea Islands proper variety. This is not a strong cotton.

FIG. 11.—SEA ISLANDS COTTON SHOWING GREAT UNIFORMITY IN THICKNESS OF FIBRES. Enlarged about 300 times.

Sea Islands, Florida.—The staple of this cotton is long and very little inferior to the best Sea Islands. In addition to
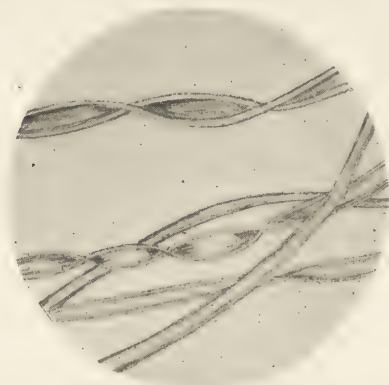

FIG. 12.—SEA ISLANDS COTTON (TAHITI). Enlarged about 300 times.

being fine and silky, it is exceptionally strong. It is used for the finest numbers of yarn, and is largely called for in the manufacture of imitation silk goods.

Georgia Sea Islands.—This cotton possesses every good quality required by the spinner. It has uniform length, strength, and fineness of staple, and regular and natural twist. It is also silky and of good colour. The diameter of the fibres

FIG. 13.—SEA ISLANDS COTTON SHOWING GREATER VARIATION IN THICKNESS OF FIBRES. Enlarged about 300 times.

is slightly in excess of the other varieties of Sea Islands cottons, being $\frac{1}{1500}''$.

Egyptian Varieties.—EGYPTIAN BROWN.—This cotton contains a considerable quantity of short fibres. Much waste in the working is a result of this. Mixing with other cottons is prevented by reason of its colour. It belongs to the Gossypium herbaceum variety. The fibres are thick in diameter compared with Sea Islands. The length of the fibres varies from $1\frac{1}{2}''$ to $1\frac{1}{8}''$.

This cotton presents little difficulty in working, being strong, of a rich golden colour, and tolerably clean.

Fig. 14 gives a very good idea of the variations in diameter of Brown Egyptian as compared with other varieties grown in Egypt. Fig. 14*a* shows Brown Egyptian under four different conditions.

EGYPTIAN WHITE.—This class of cotton is mainly produced from American seed. It is weaker than the brown variety, and its staple, though rough, is fairly uniform and regular. The diameter, as shown under the microscope, is thicker than the variety just described. Unripe fibres are frequently found in this class. Its colour is that of a light yellow.
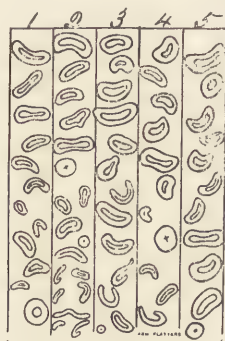

FIG. 14.—EGYPTIAN COTTON SECTIONS.
Scale $\frac{1}{1000}$″ × 280 diameters.
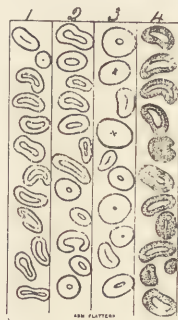1. Brown ; 2. White ; 3. Gallini ;
4. Ashmouni ; 5. Smyrna. (Flatters.)

FIG 14*a*.—BROWN EGYPTIAN COTTON.
Scale $\frac{1}{1000}$″ × 280 diameters.
1. Raw state ; 2. Bleached ; 3. Mer-
cerised ; 4. Dyed. (Flatters.)

The average length of fibre is shorter than that of the brown Egyptian variety.

At the present time (1896) a great proportion of this cotton is going to Russia.

GALLINI.—Undoubtedly this variety ranks as the best of Egyptian cottons. For length of fibre it comes next to that of Sea Islands. It is grown from Sea Islands seed, and belongs to the Gossypium Barbadense. For strength and colour it ranks very high, and is used for fine counts.

ASHMOUNI is a variety of Egyptian cotton which is the commonest, yet it is the most valuable. It is exceptionally strong-fibred.

It does not appear that very much of this cotton is now

cultivated. Certainly this is true as compared with the quantity of Brown Egyptian cultivated.

SMYRNA.—This is hard in staple, and is of the herbaceous type. It is usually rather yellow, and not so suitable for mixing. Occasionally it is very dirty, but, generally speaking, may be taken to be fairly clean. The convolutions seen under the microscope are often irregular. In thickness it is about equal to the White Egyptian variety.
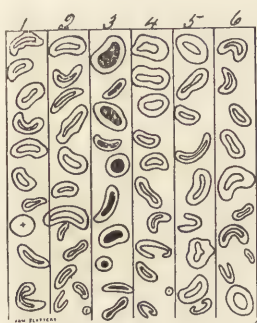

FIG. 15.—PERUVIAN AND AMERICAN COTTONS. Scale $\frac{1}{1000}''$ × 280 diameters.

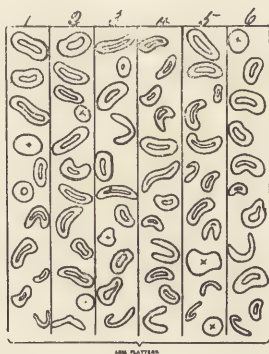1. Peruvian rough ; 2. Peruvian smooth ; 3. Peruvian red ; 4. Ordinary American; 5. Uplands; 6. Texas. (Flatters.)

FIG. 16.—AMÉRICAN COTTONS SHOWING GREAT VARIATION IN DIAMETERS OF FIBRES. Scale $\frac{1}{1000}'$ × 280 diameters

1. Orleans ; 2. Benders ; 3. Memphis ; 4. Peelers ; 5. Nashville ; 6. Allan seed. (Flatters.)

Peruvian Varieties.—PERUVIAN ROUGH.—Rough Peruvian cotton is usually mixed with Brazilian cotton. The staple is fairly long, is creamy in colour, but a little shorter than the smooth variety. It is also wiry in its nature, and cannot be said to belong to the strong cottons.

PERUVIAN SMOOTH.—This variety mixes best with soft American, such as Orleans. It is moderately short in length, but thick.

RED PERUVIAN.—This type is of a rough nature, and is used for yarns that require dyeing.

American U. S. Varieties.—Uplands.—Not very strong, and soft in staple.

Texas.—Firmer in staple than Uplands, but contains more leaf.

Orleans.—The best of American cottons, and most regular in natural twist. Some lots are very white but leafy, others creamy and clean.

Benders.—Of particularly good staple, though it is often very dirty.

Peelers.—This variety is exceedingly white, and of a long and silky staple. One important use to which this class is put is that of velvet-making.
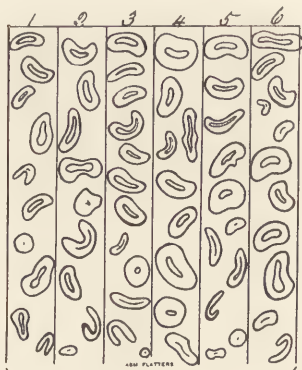

Fig. 17.—Brazilian Cottons showing great Variation in thickness in Diameters. Scale $\frac{1}{1000}'' \times 280$ diameters.

1. Rio Grande ; 2. Paraiba ; 3. Maranham ; 4. Maceio ; 5. Ceara ; 6. Pernam. (Flatters.)

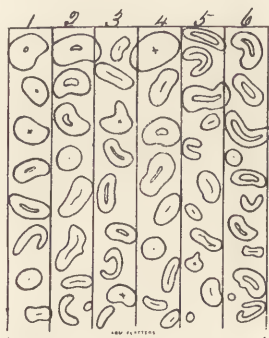Fig. 18. — East Indian Cottons showing abnormally thick Diameters. Scale $\frac{1}{1000}'' \times 280$ diameters.

1. Rangoon ; 2. Assam ; 3. Broach ; 4. Bengal ; 5. Tinnevelly ; 6. Dharwar. (Flatters.)

Brazilian Varieties.—Paraiba cotton is generally very dirty, and hence less valuable.

Maranhams.—This is good in colour, of a rough nature, short and thick.

Maceio.—Like the two preceding varieties, this belongs to

the Gossypium Peruvianum variety, as do the other Brazilian types to be described. This is softer and rather shorter than Pernams.

CEARA.—This is very similar to Maranhams and Maceio.

PERNAMS.—The finest of the Brazilian types. It is longer in fibre than other Brazilian cottons. The staple is rough and wiry in nature.

East Indian Varieties.—COMPTAH is the poorest of Indian cottons.

FIG. 19.—EAST INDIAN COTTON (TINNEVELLY) SHOWING DIAMETER ON MICROMETRIC SCALE, WHICH IS $\frac{1}{1000}''$ × 280 DIAMETERS. (Flatters.)

FIG. 20.—EAST INDIAN COTTON SHOWING THICK DIAMETERS. Scale $\frac{1}{1000}''$ × 280 diameters.

7. Comptah ; 8. Oomrawuttee ; 9. Hingunghat ; 10. Scinde ; 11. Dhollerah. (Flatters.)

DHARWAR contains much unripe and flat fibre.

SCINDE fibres. Indian types nearly all belong to the herbaceous family. The first-named Comptah often contains impurities, and the second Dharwar broken fibres. The last-named Scinde is the poorest of the three. Reference to the figure shows the diameters to be in excess of any previously mentioned.

BROACH.—This cotton is usually of good colour, and of

D

American U. S. Varieties.—Uplands.—Not very strong, and soft in staple.

Texas.—Firmer in staple than Uplands, but contains more leaf.

Orleans.—The best of American cottons, and most regular in natural twist. Some lots are very white but leafy, others creamy and clean.

Benders.—Of particularly good staple, though it is often very dirty.

Peelers.—This variety is exceedingly white, and of a long and silky staple. One important use to which this class is put is that of velvet-making.

Fig. 17.—Brazilian Cottons showing great Variation in thickness in Diameters. Scale $\frac{1}{1000}''$ × 280 diameters.

1. Rio Grande ; 2. Paraiba ; 3. Maranham ; 4. Maceio ; 5. Ceara ; 6. Pernam. (Flatters.)

Fig. 18. — East Indian Cottons showing abnormally thick Diameters. Scale $\frac{1}{1000}''$ × 280 diameters.

1. Rangoon ; 2. Assam ; 3. Broach ; 4. Bengal ; 5. Tinnevelly ; 6. Dharwar. (Flatters.)

Brazilian Varieties.—Paraiba cotton is generally very dirty, and hence less valuable.

Maranhams.—This is good in colour, of a rough nature, short and thick.

Maceio.—Like the two preceding varieties, this belongs to

the Gossypium Peruvianum variety, as do the other Brazilian types to be described. This is softer and rather shorter than Pernams.

CEARA.—This is very similar to Maranhams and Maceio.

PERNAMS.—The finest of the Brazilian types. It is longer in fibre than other Brazilian cottons. The staple is rough and wiry in nature.

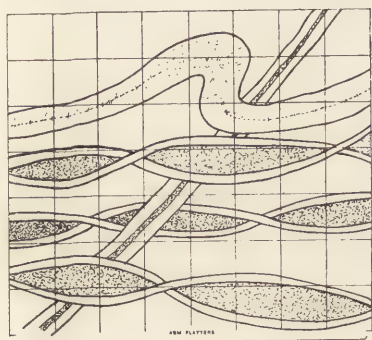**East Indian Varieties.**—COMPTAH is the poorest of Indian cottons.

FIG. 19.—EAST INDIAN COTTON (TINNEVELLY) SHOWING DIAMETER ON MICROMETRIC SCALE, WHICH IS $\frac{1}{1000}''$ × 280 DIAMETERS. (Flatters.)
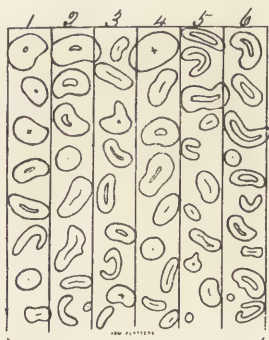

FIG. 20.—EAST INDIAN COTTON SHOWING THICK DIAMETERS. Scale $\frac{1}{1000}''$ × 280 diameters.

7. Comptah ; 8. Oomrawuttee ; 9. Hingunghat ; 10. Scinde ; 11. Dhollerah. (Flatters.)

DHARWAR contains much unripe and flat fibre.

SCINDE fibres. Indian types nearly all belong to the herbaceous family. The first-named Comptah often contains impurities, and the second Dharwar broken fibres. The last-named Scinde is the poorest of the three. Reference to the figure shows the diameters to be in excess of any previously mentioned.

BROACH.—This cotton is usually of good colour, and of

D

silky threads. Immediately, however, they are placed under a microscope of fairly high power a structure is revealed that one would never have expected.

FIG. 24.—FLORIDA SEA ISLAND COTTON, SHOWING PERFECTLY RIPE FIBRES

Some of the fibres appear like thin flattened tubes, and are not unlike microscopic ribbons. Others in the same field have
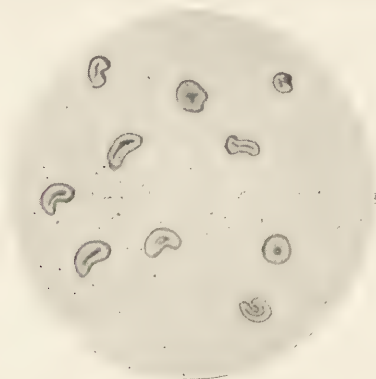
FIG. 25.—TRANSVERSE SECTIONS OF INDIAN COTTON SHOWING CENTRAL CANALS.

definite and decided twists in them, similar to those shown in the diagram of Florida sea islands; *see* fig. 24. All do not appear

to be equally and regularly convoluted ; in fact, when they come
to be very carefully examined, it becomes a matter of great diffi-
culty to find two fibres exactly alike in form, length, thickness,
and number of twists. It should be noted that this twisted
or corkscrew-like form is characteristic of most fully ripe and
properly developed fibres, but transversely the centre of the
section appears to be darker than the walls of the fibre (*see* fig.
25), and undoubtedly this centre acted as a canal, up and down
which the protoplasmic and other matters circulated, when the
fibre formed a part of the living plant.

Irregular Formations in Cotton Fibres.—In the
following figures are shown unusual formations sometimes found
when examining fibres under the microscope. Fig. 26 shows
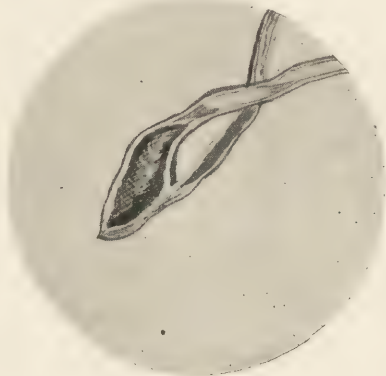
FIG. 26.—BIFURCATED COTTON FIBRE.

a bifurcated fibre in which the division is very clearly defined.
Such a formation is by no means desirable for spinning pur-
poses.

In fig. 27 is illustrated a malformation of the fibre, which
renders it of little value for commercial purposes, and indicates
one way in which waste may be expected in cotton spinning.

Figs. 28 and 29 are extremely interesting, conveying a clear idea of the irregular apices and extremities of many of the fibres.
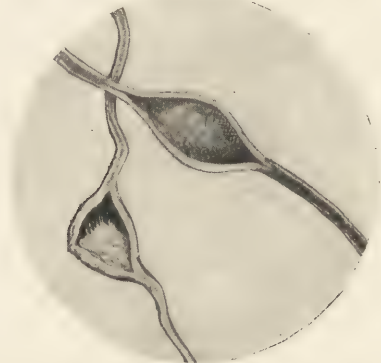
FIG. 27.—COTTON FIBRES SHOWING MALFORMATION.

Other Fibres.—The great leading characteristic which above all others distinguishes the cotton fibre from other vege-

FIG. 28.—IRREGULAR ENDS OF FIBRES.   FIG. 29.—IRREGULAR ENDS OF FIBRES.

table and animal fibres used for making thread is the presence of natural twist. By means of this natural twist the use of the

microscope will enable the student to distinguish the cotton fibre in any fabric. Several leading fibres are shown in the following sketches. Fig. 30 shows unripe and ripe cotton fibre in contrast. At A is shown a perfectly convoluted fibre, and this shows up very clearly its leading characteristics. At B unripe fibres are shown.
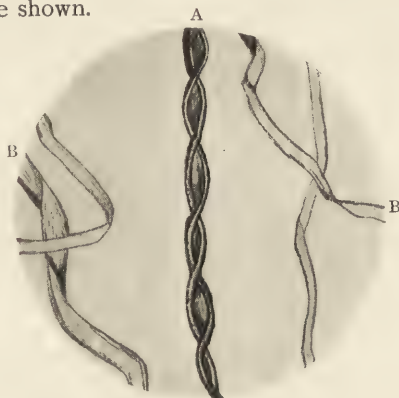
FIG. 30.—RIPE FIBRE SHOWN AT A; UNRIPE AT B.

In the next illustrations, figs. 31 and 32, are seen longitudinal and transverse sections of flax. Although such fibres make linen thread, which is much stronger than cotton, yet, if the individual fibres were cut down to the same length as, say, American cotton fibres, they would only be capable of being made into thread with the greatest difficulty, if, indeed, at all. This is chiefly because they are without natural twist.

In the next illustration, fig. 33, are shown longitudinal sections of fibres of wool and silk. It is well known that these can be made into goods of a most superior quality, and they are frequently mixed with cotton threads because of the less cost of cotton and the ease with which it can be incorporated with other fibres.

Wool fibres contain a vast number of serrations, which in

some measure fulfil the same functions as the convolutions in cotton fibres, and assist materially in making a good thread.
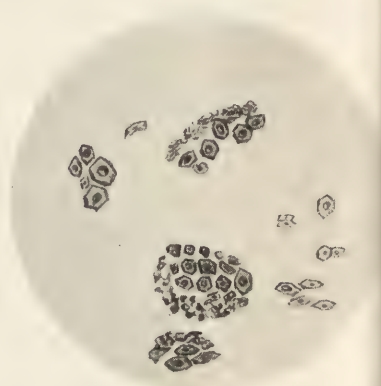
FIG. 31. - IRISH FLAX. LONGITUDINAL SECTION.   FIG. 32.—IRISH FLAX. TRANSVERSE SECTION.

Cotton, as has been observed, is largely mixed with other fibres to produce cheaper articles, and it may be profitable to quote
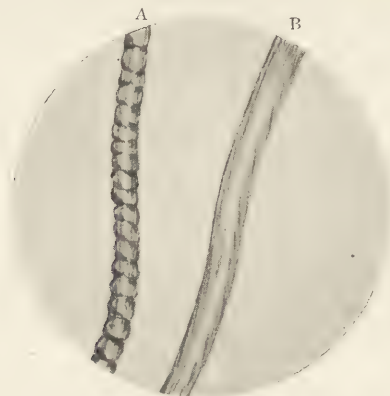
FIG. 33.—LONGITUDINAL SECTION OF SILK AND WOOL. THE WOOL IS SHOWN AT A; THE SILK AT B.

Mr. Monie in reference to the method of determining whether a woollen or linen fabric contains cotton : ' Place a sample of

the fabric to be tested in a mixture of two parts of sulphuric acid and one part of saltpetre for eight or ten minutes. After removing it wash thoroughly and dry. Then immerse it in a bath of ether containing alcohol, which has the effect of dissolving the cotton (if there be any present), while the woollen or linen fibres remain uninjured.'

'To distinguish wool and silk fibres from cotton and flax : Treat a sample of the material with picric acid, which will have the effect of dyeing the former almost a fast yellow, while the latter will remain unaltered in colour.'

The same author gives other tests, but, as we have pre viously indicated, the best method of distinguishing the different fibres which have entered into the composition of cloth is by making an actual examination under the microscope. The appearance of woollen, silk, linen, and cotton fibres under the instrument is intelligently conveyed by the foregoing sketches.

Some other interesting points respecting the cotton fibre may be described as follows :—

When properly matured and ripe a cotton fibre is a cylindri-cally-shaped hollow vegetable cell. The end remote from the seed is generally tapering, although frequently ends are seen when under microscopic examination to be irregular, torn, and thready. These are shown in illustration, figs. 27 and 28. In the better class of cottons the tube is spirally twisted into a series of convolutions varying in number, size, and form. Examined under the microscope with a $\frac{1}{4}''$ or $\frac{1}{8}''$ objective much detail of structure may be observed. For example, in some specimens the edges of the tubes appear to be irregularly serrated. This is due to the great number of convolutions in the fibre. Running through the whole length, or nearly so, especially in the ripened fibres, is a central canal or duct. The main purpose which this fulfils is to convey to the cell walls the juices which thicken and fill up the outer wall of the

thread. The advantage which obtains because of the natural twist possessed by most cottons is obvious. The clinging of threads may be clearly demonstrated by taking two fibres of good length between the finger and thumb of each hand and placing the fibres lengthways over and touching each other. Now give a twist or two, and the two fibres become locked in each other.

It was this particular clinging property that first suggested the making of a continuous thread.

Accounts of first attempts at spinning all show that this characteristic of the fibre was very early known.

The name of boll is given to the cotton pod when properly developed and opened. It is easily possible to find in the same pod fibres which are ripe, half ripe, and unripe. The latter may readily be recognised by their ribbon-like character, with little or no twist, translucent to a great degree, and with no central canal. Perfectly ripe cotton fibre consists almost entirely of pure cellulose. It has little chemical affinity for any reagents except very strong acids or alkalies. The chemical formula for cellulose is $C_6H_{10}O_5$, or, more exactly—

Carbon	.	.	.	.	44·444
Hydrogen	.	.	.	.	6·173
Oxygen	.	.	.	.	49·383
					100 parts.

There is associated with the seed of the cotton fibre, and also to some extent with the fibre itself, a waxy oil, the quantity of which varies with the season and the ripeness of the boll. Dr. Bowman says ' large quantities of this cotton seed oil are expressed from the seeds after the process of ginning, so that it now forms an important article of commerce. The presence

of this oily wax to a greater or less extent upon the surface of the fibres, and also in the cells, probably explains to some extent why we have to get a somewhat high temperature in cotton spinning rooms.' This, it is well known, is more essential for fine spinning than in the case of lower numbers. It will be readily conceived that with a low temperature the oil tends to solidify and become gummy, and hinders the perfect drawing of the fibre. Its presence in a liquefied form assists the natural moisture of the cotton fibre in making the latter more pliable and elastic, and rendering it more subject to the processes of cotton manufacture. Dr. Bowman also says : 'Upon the presence of this oil depends the " setting " process which all cotton fibres require after they are spun into yarn in order to increase its strength and take away the curl produced by the twist in the thread—a process which, in the case of single yarns, is usually accomplished by keeping them for some time in a cold and moist place, where the natural oil becomes stiffened and dry after the high temperature to which it has been subjected in spinning, and in the case of yarns for doubling purposes by subjecting them to a high temperature under steam pressure before the process of doubling the threads. There is also a certain time required before the fibres, which have been subjected to torsion in the putting in of the twist, acquire a permanent set in the new position which their substance is forced to assume in the thread. A part of the setting process also depends upon the subsidence of the electrical excitement which is induced in the hair by the friction to which it is subject in the manufacturing process. This is often seen in winter time, in dry frosty weather, especially in combed yarns, where the fibres are mechanically drawn out by the action of combing, and this electrical excitement renders them wild and hairy until they have been left for some time in a

moist place or in a vacuum. This action can be prevented to a certain extent by placing the machinery in metallic connection with the steam or gas pipes with a wire—the latter is best.' The foregoing quotation has been more particularly selected because of the light which it throws upon the important practical subject of ' damping.'

CHAPTER V

Cotton Compressing.—When the cotton has been ginned sufficiently (and this work is often done now on the plantation) it is baled roughly and sent on to the 'compressors.' The authors are indebted to Messrs. S. B. Steers & Co., of New Orleans, for the following description of the MORSE COTTON COMPRESSOR; *see* fig. 34. The principal reasons for which the Morse compressor has become such a success are its simplicity, rapidity of work, and durability.

Several of the first compressors ever built have been running over 12 years, and have cost practically nothing for repairs, and have not been stopped for a single day. There is a direct application of steam from boilers to the 90″ cylinder, which forces up the piston head, to which are attached the four arms, the lower plates being attached to them by 15″ pins. The sectors are so made that seven powers of the lever are obtained. Therefore for every 1 lb. pressure of steam 7 lbs. pressure is obtained on the bale.

It is possible with this to compress a bale of cotton to a density of 70 lbs. or 80 lbs. to the cubic foot measured in the press.

American cotton is only tied with six or seven bands. A great amount of density is therefore lost when the pressure is removed, the average being 30 lbs. to the cubic foot after expansion has taken place. If the same number of bands were used as in Indian cottons, viz. 13, it would be possible to retain much of the initial density. Another factor which tends
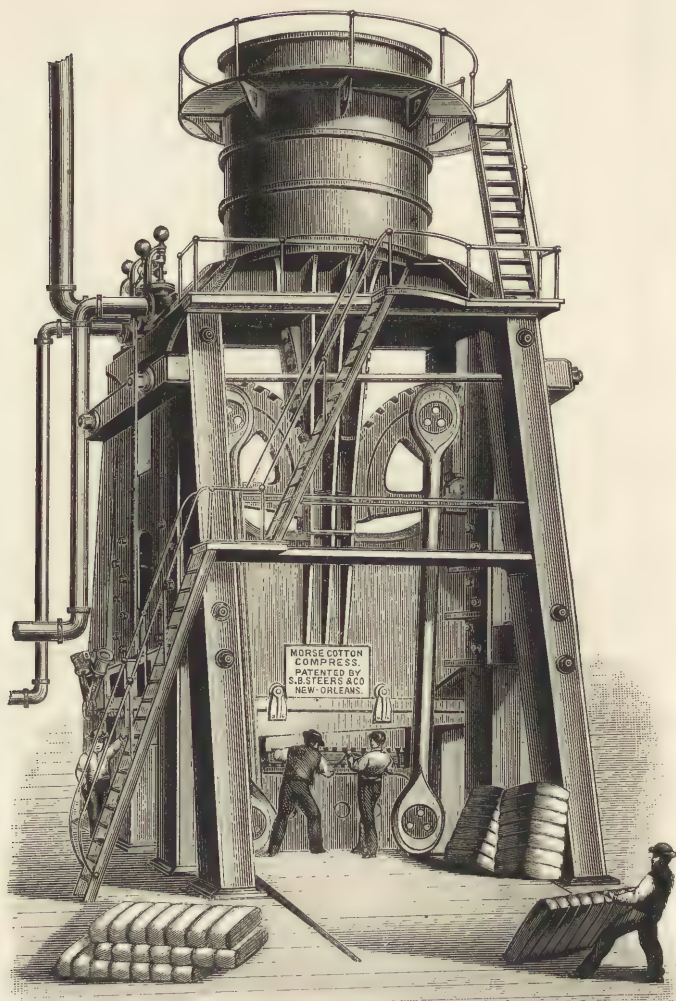
FIG. 34.—MORSE COTTON COMPRESSOR, SHOWING METHOD OF BALING
AMERICAN COTTON.

to decreased density is the rapidity with which the work is turned out. If more time were allowed in banding the bales the bands could be put on much tighter. No less than 1,000 bales have been compressed and banded in 10 hours, and the records show that nearly double the amount has been pressed in the same time.

Cotton bales when they come from the plantation press measure about 5 feet long, 30 inches wide, and 4 feet deep. By the Morse compressor this 4 feet can be reduced to 7 inches. The bale afterwards expands to 12 inches or thereabouts. It has been urged that the great pressure would end in injury to the fibre. After exhaustive inquiries and experiments, the firm named on page 45 state that the fibre is smoother, and does not in any way suffer so far as its strength is concerned.

It may be interesting to state the number of men required about a compressor when in full working order :—

One lever-man, who works the press and acts as engineer.

Two sew-boys, who sew the heads of the bales.

Three or four tiers, who tie the cotton.

Two banders, who push the bands through the grooves back to the tiers. (At some presses there are three or four pressers on either side.)

Two men to truck cotton to the press.

One man to cut ends of ties after removal of bale from press.

Two men to load the bales of cotton on the floats or railroad cars after compressing.

During the last few years there has been a very strong tendency to press bales of cotton so as to be cylindrical, *i.e.* to have a round transverse section instead of a rectangular transverse section. These are of greater or less length according to the type of machine employed. In one instance the bale is a short cylinder with a length only about three-fourths

of its diameter, the latter being about 32 inches. These bales therefore can readily be handled, being usually rolled about the floor, and, in spite of their small dimensions, weighing upwards of 470 lbs. The length of about 24 inches has been purposely determined upon, so that two of them can be placed side by side and be the right width for feeding to an opening machine, and it is asserted they can be unwound without licking. Recently Major Hammond of North Carolina, and Mr. Thomas of Lowell, Mass., U.S.A., strongly advocated this particular form of bale.

In our opinion it would be a really good thing if such bales could be delivered to us in this country in the same condition

FIG. 35.—CYLINDRICAL BALES OF COTTON NOW BEING EXPORTED FROM AMERICA.

and on the same terms as we get the oblong bales. They could then be placed whole on the lattice of the bale breaker and unwound automatically, just as the laps at the back of the carding engine are unwound. The new style of bales is almost fireproof, both on account of their peculiar build and because the whole of the air is practically pressed out of them. It remains to be seen whether cylindrical bales of cotton will ever become popular.

We have it upon the high authority of such practical men as Mr. John Butterworth, of Shaw, near Oldham, that very great baling pressures do not damage the cotton fibre.

CHAPTER VI

Faults in Cottons. Nep.—A question at the recent (1896) City and Guilds of London Institutes examination was as follows :—' What is nep ? In what stages in the preparation of cotton is it chiefly formed, and how ?'

The question may be answered somewhat as follows :—

' Nep ' may be defined as being the rolling up or entanglement of fibre into small white specks something like grains of sand for size. It may be either natural or artificial. As regards the former, it may be understood that there is always a greater or less proportion of fibre in what may be termed a raw or green state, although the bulk of the cotton may be quite ready for picking. These undeveloped fibres, when the cotton is picked, have a strong tendency to curl up and contract and entwine themselves round and among the good fibre in the small white specks to which we apply the term ' nep.' As regards artificial nep, this is produced to a greater or less extent in several of the earlier machines used in the preparation of cotton. There is no doubt that some of the ginning machines are responsible for a large amount of nep. The saw-gin, so largely used in the Southern States of the American Union, is notably guilty of making a large amount of nep, particularly if the saws are badly set, or the machine—as often happens—is otherwise out of order. Some of the more modern styles of gin are also far from being free from the evil of making nep. Often the fibres are operated upon too long by the blades of some new ginning machine, with the

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natural result that neps are made. In the scutching room neps are often made by subjecting cotton to an excessive amount of beating, or by the beater blades being out of order, or sometimes by trying to get too much cotton through one machine. The carding engine is often a fruitful source of nepped fibre, owing to carding too heavy, by neglecting stripping and grinding, by bad setting of the flats, rollers and clearers, doffer, and doffer comb; also by sometimes allowing the web to become broken and to fill up all the space between the doffer and the calender roller, until the cotton is carried over the doffer and fills up the doffer comb, so that some portion of the fibre remains subject to the action of the comb for some time. Overloading the wire is a fruitful source of nep. It may be said that there is scarcely any defect that is more difficult to get rid of than nep, when once it is made, the comber in this respect being much more efficient than the card.

Unripe Fibres.—These may be broadly divided into two classes—absolutely dead, or unripe, fibres, and what may be termed half-ripe fibres. These two types are shown in section in fig. 36.

Dead cotton appears under the microscope to be extremely thin and transparent, and generally with little or no twist in it, and is of little use for the purposes of manufacture. Half-ripe fibres are weaker and shorter than fully ripe fibres. They are flat and ribbon-like, and contain little natural twist, and it has been proved that they will not take certain dyes.

Hence there are certain classes of goods that cannot be made from cotton of this sort of sufficient excellence to compete against goods that are made from cotton that is fully ripe. Ripe cotton submits more readily either to the dyeing or bleaching process. ' All cotton fibres,' says Mr. Butterworth, ' when submitted to a strong solution of soda will crisp up

or swell, but no fibres show this feature more than ripe ones.
This feature will account for the shrinkage or running up of
piece goods in the bleaching process. This property was

FIG. 36.—SECTIONS OF HALF RIPE FIBRES AT A. UNRIPE OR DEAD FIBRES AT B.

known to the Hindoos 200 years ago, and in selecting their
cottons they always took care to select those that experience
had taught them would swell most in the process of bleaching.
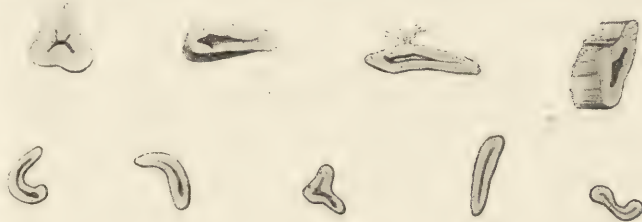

FIG. 37.—SECTIONS OF FULLY RIPE AND HALF RIPE FIBRES
Magnified $\frac{1}{250}$. (After Deschamps.)

Hence their calicoes were preferred in this country for their
lustre and softness long after we began to spin and manu-
facture.'

Ripe cotton fibres (as seen in fig. 37) are hollow nearly
throughout their entire length, the part which is not hollow being

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the end of the fibre not attached to the seed. As will be seen by reference to fig. 36, those fibres which are more or less deficient in ripeness show little or no indication of an opening through them. Their closed character excludes the dye, whereas the hollowness of the ripe fibres allows it to penetrate.

We have before stated that unripe fibre has a great tendency to curl up, or nep, and when these neps get into some makes of cloth its value is greatly deteriorated, because when such material is subjected to certain shades of dyeing these white specks refuse to take the colour and disfigure the face of the fabric.

The contrast between the three types of fibre is very clearly shown in the two preceding illustrations.

Broken Leaf. --Owing to the close proximity of the leaf to the cotton and the speed at which the cotton has necessarily to be picked, there is always a greater or less quantity of leaf taken from the plants along with the cotton. Doubtless the quantity is increased often by the carelessness of the pickers, much after the same way that bobbin and fly frame tenters will let 'thick and single' go through, and spinners and piecers will make 'nicked cops,' 'bad bottoms,' 'bad ends,' &c. Unfortunately the leaf gets broken up in the ginning process, making it a more difficult operation to afterwards extract the leaf.

The greatest cleaning principle we have in cotton spinning is the repeated opening or drawing out of the cotton at stage after stage, so that the impurities will then fall out by the force of gravity. Leaf when broken up so fine becomes much more difficult to extract, on account of its becoming so light that it will not drop out.

Seeds.—When the cotton is first picked it is well known that over two-thirds the weight of the seed-cotton consists of seed, which is of no use whatever to the cotton spinner, and

therefore must be at once removed. It may be noted, however, that the seed is now very largely utilised for various useful and profitable purposes, such as for making fertilisers, cattle food, and cotton seed oil, the latter being a valuable commodity which has recently obtained a somewhat large sale in England.

The seed, however, must be separated from the fibre, and, as the latter adheres tenaciously to the seed, the separation is only effected by the somewhat brutal process of ginning. As a rule the gins are worked at high speeds, and overloaded with seed-cotton. Some of the seed, therefore, either broken or whole, is conveyed along with the fibre, and, being brought to the spinning mill, constitutes one of the defects in the cotton.

Broken Fibre.—Owing to the rapidity with which great masses of fibre are fed to the saws of the saw-gins, or to the rollers of other types of gin, and owing to the gins being sometimes out of order, the fibre is very liable to become gin-cut or broken. It must be remembered also that the cotton is fed in tangled masses with the fibres lying in every direction. Long-stapled fibre is much more liable to damage by this means than any other, and, as the saw-gin is notoriously liable to give gin-cut cotton, this will explain why this gin is totally unfit for the Egyptian and Sea Islands varieties of cotton. We get the bulk of our supply of cotton from America, and special stress ought to be laid on the fact that no cotton suffers more from the ginning process than this variety, and it would appear that strong measures ought to be taken to diminish the evil.

Sand and Mineral Matter.—Owing to the winds loading the cotton plants with sand at times, and other causes, such as adulteration, there is always present in cotton a greater or less proportion of sand and mineral matter. This is worse than dead loss to the cotton buyer, because he not only pays the price of cotton for sand, but its presence involves danger and expense in extracting it. Sea Islands is the most free from it,

containing only a little over one per cent. In Brown Egyptian it is present to the extent of a little more than $1\frac{1}{2}$ per cent., in Gallini rather less, and in White Egyptian rather more.

In Smooth Peruvian and in Brazilian cotton it is generally present to the extent of about 2 per cent., although in Rough Peruvian it is given at less than $1\frac{1}{2}$ per cent. Indian cotton, as might be expected, contains the highest percentage of sand, &c., ranging from less than $2\frac{1}{2}$ per cent. for Hingunghat to as much as 5 per cent. for Bengal.

In American it ranges from rather more than $1\frac{1}{2}$ per cent. for Orleans to about 2 per cent. for Uplands.

Moisture in Cottons.—Although a certain quantity of moisture is a necessary accompaniment to good commercial cotton fibres, in order to keep them soft, pliable, and elastic, the quantity present should in no case exceed 4 or 5 per cent., and this may be taken as rather a high average. Unfortunately, however, of late it has become pretty well known that systematic damping has often been resorted to in order to unduly increase its weight, and it has been no infrequent occurrence to find moisture present in cotton to the extent of 10 per cent. or more. For this reason it is advisable that fresh consignments of cotton should always be tested for moisture as soon as possible after arriving at the mill. Special ovens have been designed for this purpose. These have found considerable favour among some practical men with whom the authors are acquainted. A good practical test is to take a quantity of cotton and place it in open-made doffing skips upon the creels of the spinning machines for a few days. It will thus be in close juxtaposition to the creel bobbins in the actual atmosphere in which it will have to be worked.

By weighing the cotton before and after placing on the creel the percentage of loss can be easily calculated. It would perhaps not be unreasonable to allow it to lose 7 or 8 per cent.

in this position, owing to the heated atmosphere. The Employers' Association has before now taken up this matter of moisture, and in cases of dispute doubtless the artificial method of drying rapidly in a heated oven is commendable, as it allows of rapid tests, and reasonable allowance can be made for extra loss by overheating. When heated at about 175° F. it is found that cotton will lose 8 per cent. over its normal condition when in an ordinary atmosphere, so that any loss beyond that in the oven is easily ascertained.

It must be remembered that cotton will naturally absorb moisture or part with it according to the state of the weather, to which it may be more or less exposed. It is also worth remembering that new cotton may be expected to contain more moisture than cotton a season or a few months old, owing to natural evaporation.

Perhaps in a less degree the weather affects the cotton when it has passed through several of the processes in the mill, and its spinning properties are seriously diminished if it be over-dried. It is stated on good authority that from 5 to $7\frac{1}{2}$ per cent. less production takes place when east or dry frosty winds prevail.

If bobbins from the creel of the roving frame be placed in a dry warm oven for a few days with a temperature of about 120° F. it will be found that only with the greatest difficulty will the ends be kept up at the mule or ring frame. The appearance of the yarn will be parched and brittle, and rough to the touch, and the threads will refuse to stand the strain of 'gain' and 'ratch.' If the same bobbins, however, be allowed to remain for a few days in their ordinary atmosphere it may be expected that they will regain all or nearly all their original moisture and spinning qualities.

A warm humid atmosphere is the best possible kind for the good spinning of cotton. In a cold atmosphere the oil in

the fibres becomes partly solidified, and makes the cotton liable to stick to the rollers, &c. A somewhat high temperature liquefies this oily substance and reduces its viscous or sticky properties. More is said about moisture in the chapter dealing with 'Humidity'

Testing of Cotton passing through Machines.— Every fresh purchase of cotton ought to be carefully tested by actually passing a portion of the cotton through all the machines as far as the card, first having them thoroughly cleaned. The particulars ought to be entered up for future reference in the 'Cotton testing book' specially kept for the purpose. It is not customary to take the test for loss by this method further than the card, as, with the exception of the comber, which takes out such a large percentage of the short fibre, there is, comparatively, little loss in any of the machines subsequent to the carding engine. The following is a record of an actual test of cotton made by Mr. T. Thornley, of Bolton.

TEST OF EGYPTIAN COTTON. BALE MARK C.S.T.

Number of bale, 23 ; invoice weight, 6 cwt. 3 qrs. 6 lbs.

,, ,, steel bands, 7 ; actual weight, 6 cwt. 3 qrs. 6 lbs. 100 lbs. were placed through exhaust opener and a single scutcher which had previously been thoroughly cleaned.

The laps, after passing the scutcher, weighed 94 lbs. 4 ozs.
,, droppings weighed . . . . 2 lbs. 8 oz.
Invisible loss . . . . . . 3 lbs. 4 oz.
100 lbs.

The laps fed to the revolving flat carding engine weighed 94 lbs. 4 ozs.

The sliver from the card weighed . 90 lbs. 9 ozs.
The strips ,, ,, ,, ,, . 1 lb. 14 ozs.
The fly ,, ,, ,, ,, . 1 lb. 5 ozs.
Invisible loss . . . . 8 ozs.
94 lbs. 4 ozs.

Summary of Cotton Facts.—It is deemed advisable, after dealing in detail with the subject of cotton, to give a brief epitome of the principal commercial facts appertaining to the subject.

Cotton is the fibrous covering of the seed of certain plants which grow in various regions extending from 45 degrees north to 35 degrees south of the equator. The four chief cotton-growing countries in the order of their importance are the Southern States of the American Union, India, Egypt, and Brazil. Nearly all cotton used in Europe and America is grown in these countries. Some cotton, however, is grown in the West Indies, the west coast of Africa, and China. The characteristics which constitute good commercial cottons are length of staple, fineness, strength, colour, cleanliness, freedom from nep, silkiness in appearance, and uniformity. Sea Islands is by far the best cotton extant, and is cultivated chiefly on the coast of Florida, Georgia, South Carolina, the Bahama Islands, and on the Florida mainland. It is generally employed for counts of yarn ranging from 180's to 300's, although it is occasionally used for good qualities of lower numbers. It owes its superiority to a combination of circumstances, including the best of seed, soil, climate, irrigation, drainage, and care in picking and ginning.

Egyptian ranks next to Sea Islands in quality and price, there being three chief varieties. These are Gallini, which is the best ; Brown, which is next in quality ; and lastly White. Gallini is from Sea Islands seed, but is inferior to that cotton as regards regularity of twist, &c., and in containing much short and undeveloped fibre. Brown Egyptian is by far the most extensively cultivated in Egypt, and is an exceedingly useful cotton. Owing to its colour it is seldom mixed with other cottons, as it is liable to give striped yarn and cloth. White Egyptian ranks in commercial value a little superior to

the Brazilian cotton, and is often used for mixing with Brazilian and American, and in unions of linen and cotton. At the present time not much of it is being used in England, a large proportion going to Russia. Egyptian cotton plants depend largely upon the overflow of the Nile for their moisture, and a good overflow tends to give a good crop of cotton, whereas a poor overflow has the opposite effect.

Brazilian and Peruvian cottons rank next in quality to Egyptian, and are characterised chiefly by a dryness, harshness, and roughness in their structure and feel. Yarns spun from these cottons are often used by hosiery manufacturers. The weight of the bales of Brazilian cotton is only about 170 lbs., whereas Egyptian would weigh upwards of 700 lbs. 'Santos' cotton is cultivated to some extent in Brazil from American seed.

More cotton is produced in America than is obtained from all the rest of the world put together. Out of this cotton are made the numerous classes of goods for common domestic use, as it is easily made into good, cheap, and reliable articles. Nearly all the great bulk of medium or garden numbers of yarn are made from American cotton. The crop for 1895 reached about 9,000,000 bales, and last year—1896—it was over 7,000,000. It may be regarded as the standard by which other cottons are compared, and its price per pound often has a distinct effect upon the prices of the other cottons. It is grown over a wide area, embracing North and South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, Tennessee, Arkansas, and Texas. The latter State constitutes the largest cotton field in the world, embracing about 6,000,000 acres, whilst the total acreage planted for American cotton is over 20,000,000, estimated roughly.

Indian cottons, generally speaking, are the dirtiest and shortest in the fibre of any that are in use to any great

extent. Continental countries are the largest buyers of Indian cotton, over one half of the entire crop being absorbed in their mills alone. These Indian cottons are often called Surat cottons, and first began to be extensively used in England during the American Civil War. The total crop reaches about 2,500,000 bales, roughly speaking, of which India herself will use over $\frac{3}{4}$ of a million, England $\frac{1}{4}$ of a million, and the Continent the rest. A bale may be about 400 lbs. as against 500 lbs. for American. The best Indian cotton is Hingunghat, and the worst is Bengal or Scinde. Here is a brief table of the chief cottons : —

Class of cotton	Mean length of fibre	Mean diameter of fibre	Comparative strength of fibre in grains
Sea Islands . . .	$1\frac{3}{4}$ in.	$\frac{1}{1570}$ in.	100
Egyptian (Brown) . .	$1\cdot4$ in.	$\frac{1}{1526}$ in.	150
Brazilian (Pernams) .	$1\cdot2$ in.	$\frac{1}{1260}$ in.	160
American . . .	$1\cdot0$ in.	$\frac{1}{1310}$ in.	140
Indian . . .	$\cdot9$ in.	$\frac{1}{1185}$ in.	150

Cottons in commerce are not known by their botanical names of Barbadense (Sea Islands), Hirsutum (American), Herbaceum (Indian, &c.), Arboreum (Brazilian), but by the names of the places where they are grown. Thus the chief cottons are as follows :—American : Uplands, Mobile, Orleans, and Texas. South American are : Pernams, Maranhams, Ceara, Aracata, Paraiba, Bahia, and Maceo. Indian : Hingunghat, Dharwhar, Broach, Dhollerah, Oomras, Comptah, Scinde, Bengal, Rangoon, and Tinnevelly. There are some exceptions to the rule, as, for instance, Egyptian is generally divided into Gallini, Brown, and White.

The chief defects and impurities present more or less in cotton are broken fibre, nep, leaf, seed, sand and mineral matter, short fibre, unripe fibre and stringy cotton. The fibres

on different parts of the same seed vary in length, the longest fibres being on the crown or top of the seed and the shortest fibres on the base of the seed.

Nep and bearded motes are two of the most difficult matters possible to get out of cotton, and they are frequently to be observed in otherwise good webs or slivers from the card-ing engine. Nep may be either artificial or natural. The latter is often unripe fibre which has contracted by heat ; the former is often caused by defective ginning and carding or scutching. It is the rolling up or entanglement of fibre into small white specks as small as grains of sand. Bearded motes are portions of imperfect seed, and the beard upon them adheres to the slivers, roving and yarn, and hence the difficulty of removal.

Cotton is adulterated by fine white and reddish sand and other weighty foreign matter, and also with water. The loss from natural damp in England may be taken at about 6 per cent. average, and a greater proportion than this may be regarded with suspicion. The total loss from all causes in passing American cotton through all processes may average 16 or 17 per cent., but some of this is caused by bobbin waste, underclearer wastes, &c. In this average the scutching room may be responsible for about 7 or 8 per cent., the carding engine 5 per cent., the drawing and slubbing frames $1\frac{1}{2}$ or 2 per cent., and the rest may be made at the after processes at something like $\frac{1}{2}$ per cent. at each different machine, although this is often exceeded.

Cotton fibres are reckoned to be about one thickness for something like three-quarters or more of their length, and then to taper off somewhat abruptly. These weak ends, which are at the apex or point furthest removed from the seed, are solid, whereas the other part of each fibre is hollow. They break off

easily in passing through the various machines, and along with short and unripe fibre form flat and other waste.

Cotton during growth is often damaged by the prevalence of frosty weather, by too much rain, or a deficiency of water supply, by cold winds, and by the ravages of destructive insects, such as the caterpillar and boll-caterpillar. Successful cultivation of cotton depends upon a number of circumstances, such as the seed, the soil, the atmospherical temperature, rainfall, irrigation, drainage, and the use of fertilisers. Damp, clayey soil does not afford sufficient nutriment for the fibres, and a somewhat similar remark applies to a very dry soil. Some writers say that natural twist is present in the fibres to the extent of from 100 to 300 turns per inch, while others give it as being from 300 to 800 turns per inch. There is no doubt that it is present to a great extent in all good fibres, and most materially assists in enabling us to produce the strong, fine cotton yarns that are placed on the market in such large quantities.

Speaking generally, cotton is sown in March, April, and May. It blooms in June and July, and is ready for picking in August, September, and October. It is said to require about 80 days after sowing before flowering, and from fall of flower to ripening of pod from six to eight weeks ; and the plant requires about seven months for germination, growth, flowering, and full maturing of fruit. These particulars vary with different districts. The picking season is the busiest time of all on a cotton plantation, as damage by sun, wind, rain, and dust is prevented by quickly picking the cotton after the bolls have opened. In the markets cottons are classified according to their qualities somewhat as follows :—American : Middling fair, good middling, middling, low middling, and good ordinary. Brazilian generally are divided into good fair, fair, middling

fair ; Egyptian into good, good fair, fair ; and Indian into fine, good, good fair, and fair.

The Chief Cotton Ports of the world are as follow :— Liverpool supplies all divisions of the English home trade, although the opening of the Ship Canal promises to divert some of the trade to Manchester. Bremen supplies the German trade, which is mostly in medium American, but also some Indian. Havre on the Seine, in France, supplies the trade of that country, which is largely employed in low numbers from Surats. Amsterdam supplies Holland, whose spindles are also largely employed in the coarse trade. New York, New Orleans, Charleston, &c., supply the Americans ; and Bombay is the chief cotton port for India.

The Terms upon which cotton is usually bought in Liverpool are 10 days' credit, less $1\frac{1}{2}$ per cent. discount. If payment is made before the ten days are expired 5 per cent. interest is allowed for as many days as are saved, and if payment is deferred above ten days then five per cent. is charged for the extra days against the buyer. There are various conditions with regard to cotton falsely packed, &c. There are buying brokers and selling brokers, who have commission at the rate of one half per cent. The expression 'C.I.F.' means costs, insurance, and freight. *Spot* cottons are cottons actually at Liverpool ; *arrivals* are cottons shipped for transit or actually at sea ; *futures* are cottons bought for delivery in certain future or forward months, and it is in these that so much speculation takes place. The term *bull* is applied to buyers, and the term *bear* to sellers of futures.

CHAPTER VII

Ginning.— In all countries where cotton is cultivated it is 'ginned' before being exported. Ginning is the separation of the seeds from the fibres, and is performed by different methods. Every boll, or pod of cotton, contains seeds which, when removed, leave only about one-third of the quantity gathered from the tree as clean cotton. Two-thirds of the cotton grown and picked consist of seeds and one-third of raw material fit to be used by the spinner. Some cottons are much easier to gin than others, Egyptian being the easiest, because the seed is smooth and quickly escapes from the fibre, whereas if the seed is covered with a woolly down, as some of the American varieties are, it remains for a time entangled with the seed cotton and prevents the access of unginned cotton to the leather roller, thus diminishing the out-turn.

Various kinds of gins are in use, the most primitive ones being the Foot Roller and the Churka. Of power gins the principal are Macarthy gins, Single and Double-acting, Knife Roller gins, and Saw gins.

The Foot Roller Gin.— One of the oldest and simplest known methods of 'ginning' cotton is by means of the foot roller (fig. 38), a contrivance which, if not altogether obsolete, is used only in the Dharwar district of India. The cotton is spread over a smooth flat stone one or two feet square. An iron roller is placed on the stone, and a forward rolling motion is given to it by the foot of the worker, usually a female. Sometimes the rod is shorter and slightly taper, and then the

motion is round and round the stone. In any case, the effect is to exercise such a pressure on the seeds as to detach the fibres, the seeds being pushed away in front. The production

FIG. 38.—INDIAN FOOT ROLLER GIN.

of the foot roller is necessarily very small, amounting to 4 or 6 lbs. of clean cotton per day. This method is only suitable for the native cotton, in the cleaning of which it is employed. The seeds are very hard, and experiments made with the foot roller on American cotton have resulted in the soft seeds of that variety being crushed by the process.

The Churka Gin.—This machine is the oldest cotton cleaning machine, formerly used in all cotton-growing countries, but now probably existing in India only. In some parts of that country the small growers, or 'agriculturalists,' as they may be termed, cultivate their little plot of land, and, after the crop is ready, gin it themselves, and take it to the market or baling house. It is amongst these people that the simple and inexpensive churka is mostly used.

The main features of the 'Guzerat' churka, the commonest form of the machine, are two rollers, as shown in fig. 39, an upper one of iron about $\frac{1}{2}''$ diameter, and a lower wooden one about 2″ diameter. They are kept turning towards each other, the iron roller moving much more rapidly than the wooden one. A very small space is left between them, and as the unginned cotton comes in contact with the rollers the seeds, being unable to pass the fibres, are dragged through to the other side. The seed cannot escape so long as the fibres adhering to it are held by the rollers. When it is stripped, however, it

falls down out of the way. The Guzerat is worked by two persons. Various modifications of the churka exist all over India, sometimes worked by one and sometimes by two persons ;
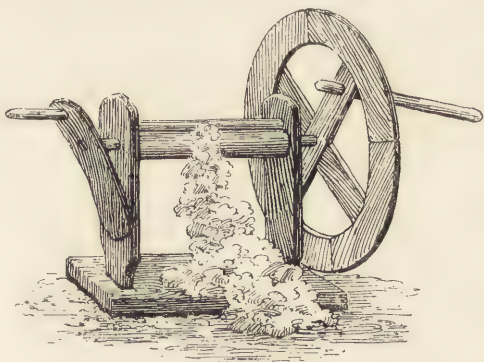

Fig. 39.—Guzerat Churka Gin, requiring Two Persons.

but, speaking generally, the average production for each man or woman engaged in the work may be put at 6 lbs. to 8 lbs. per day.

The churka illustrated in fig. 40 is worked by one person, and is by far the best in use. The Guzerat machine just described has one very great fault. The rollers being driven independently by two persons, their surface velocities rarely correspond, and the cotton between them is exposed to an injurious grinding action whenever one surface is moving quicker than the other. This defect is not experienced in the one-handed churka (fig. 40), as the rollers, both of which are of wood and of similar dimensions, are fitted with Archimedian screws. *All churkas* fed by hand are imperfect. In these machines it is impossible to keep the full length of the roller supplied with raw material, and so they are never worked up to their full capacity, although it is easy to feed too fast and clog the machine. The work produced by the churka is perhaps better than that pro·

F

duced by any other gin, old or new, but the small amount of
cotton ginned makes its general use altogether impracticable.
The fibre is as nearly as possible uninjured, because the action
in the machine is so free from any sharp bits, or cuts, or
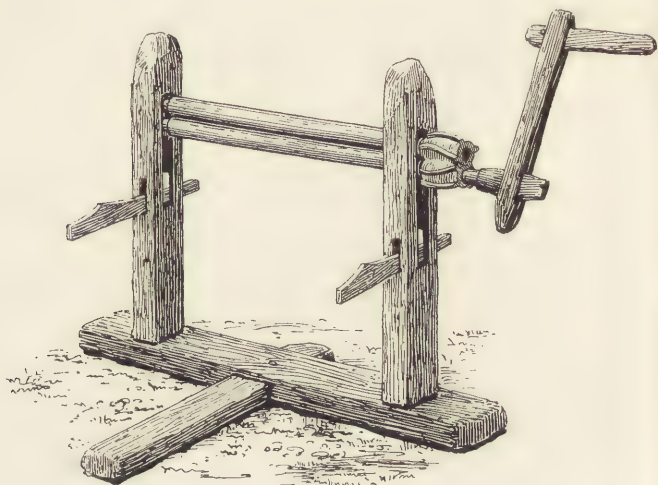tearing strains.

FIG. 40.—ONE-HANDED INDIAN CHURKA GIN.

The Macarthy Gins.—The Macarthy gin consists of a
leather roller, usually 40 inches long and 5 inches in diameter,
and two knives, one acting as a 'doctor' upon the roller, the
other oscillating rapidly by means of a crank driven from the
roller shaft. The roller is covered with walrus leather, and is
grooved spirally, so as to assist in laying hold of the fibres.
The cotton, on being pushed by the crank feeder bar o (fig. 41)
is seized by the roller A and drawn beneath the fixed blade B.
The oscillating blade F is meanwhile rapidly moving up and
down and forcibly separating the fibres from the seeds, so that
the latter are stripped, and, when no longer held by the fibres,
fall through the slots X in the grid T. The cotton can be

either cast direct upon the floor or removed as desired. The double-acting Macarthy gin has two vertically-moving blades, F and K (fig. 42), driven by the cranks R and S. When one
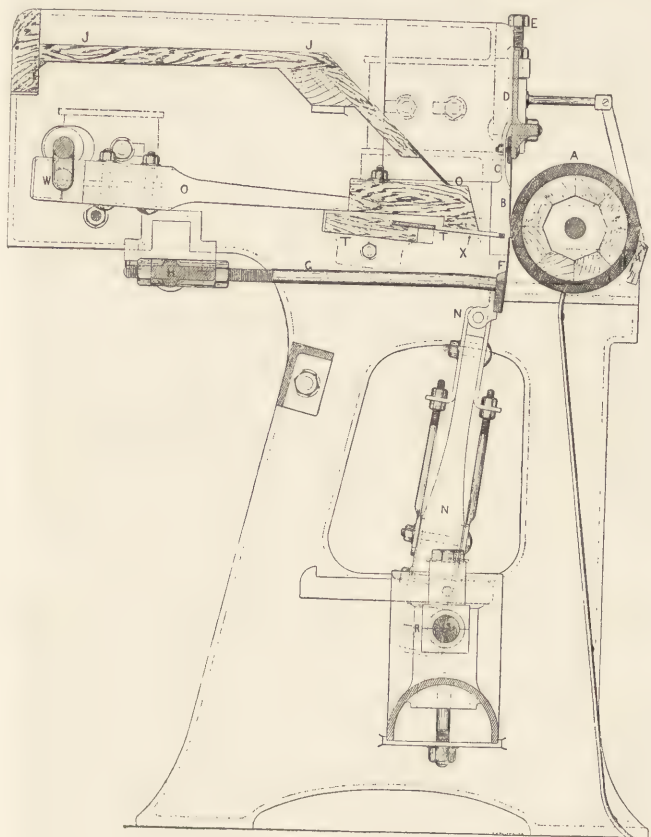
FIG. 41.—SINGLE-ACTING MACARTHY GIN.

knife is moving down the other is moving up, each revolution of the crank shaft causing two beats instead of one. The action of the machine is thus increased by increasing the number of

the beats and helping to free the seeds from the adhering tuft of fibres. The most important setting of this machine is the distance between the edge of the doctor knife and the beater

Fig. 42.—Double-acting Macarthy Gin.

knives. If set too close the staple may be broken, and if too far apart the seed is liable to get between, in which case it is crushed. The pulley on the leather roller is usually 20 inches

in diameter, and that on the crank shaft driving it 6 inches in diameter. The speed of the leather roller is 140 revolutions per minute, and that of the crank 480.

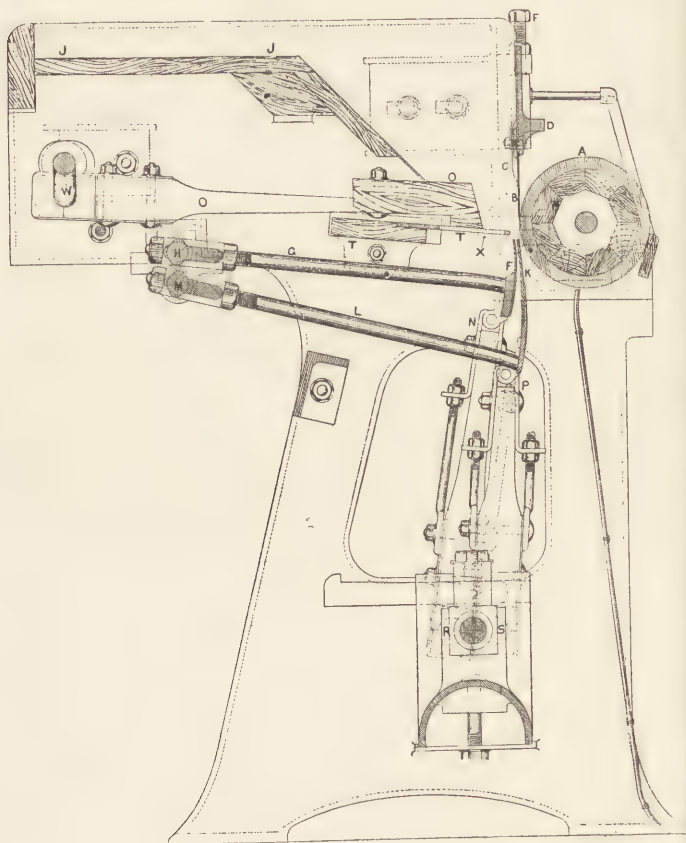**The Knife Roller Gin.**—This gin is shown in fig. 43. The leather roller A is similar in construction to that used in Macarthy gins, but there is in this machine a knife roller, B, set at about the diameter of a seed from the leather one. The cotton, when fed, falls upon the knife roller, and the shape and motion of the latter causes it to be carried under the guard C. The
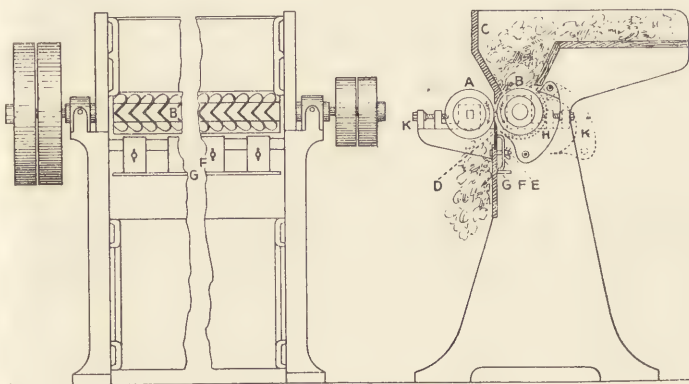
FIG. 43.—KNIFE ROLLER GIN, TWO SECTIONS.

leather roller carries the fibres under the doctor knife D, which is pressed against the leather one in such a manner as to prevent the seeds from following. The cotton is stripped, and falls in a continuous sheet from the leather roller, and the seeds are carried past the edge of the knife D into the circular grid H, the perforations in which vary in size according to the cotton treated. The shape of the knife roller blades causes the seeds to be rapidly pressed from side to side as well as downwards, thus accomplishing the work much quicker. The amount of lateral movement depends on the angle of inclination of the

blades. The machine as shown allows of many adjustments. The bearings of both rollers may be carried backwards or for-wards (to compensate for wear of the leather) by means of the screws K K. The height of the doctor knife edge can be regu-lated by setting screws in the cross-bar G. The pressure of the knife D on the leather roller can be regulated by the thumb-screw E, which, by means of the spring F, provides a yielding pressure on the roller. The knife roller gin is capable of delivering a quantity of clean cotton varying from 150 lbs. of Egyptian to 90 lbs. of Broach per hour.

Another gin, recently introduced, namely, Dobson and Roscoe's patent double cotton gin with double-action knife
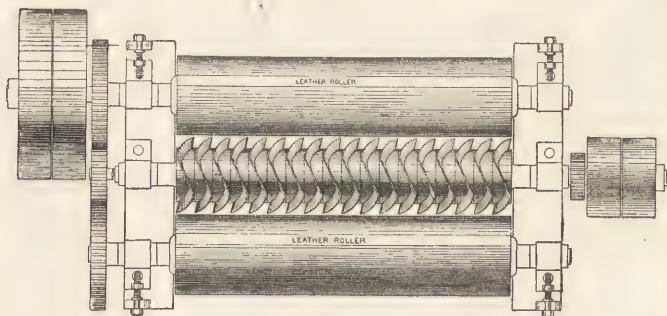
FIG. 44.—PLAN OF DOBSON AND ROSCOE'S DOUBLE COTTON GIN WITH DOUBLE-ACTION KNIFE ROLLER.

roller, has two leather rollers in place of one, as shown in plan and sectional elevation in figs. 44 and 45. The knife roller is provided with an auxiliary roller, R, which carries the cotton to the left, as shown by the arrow. During work the space between each blade on the knife roller is full of seed cotton, and only those fibres brought within the range of A are laid hold of and drawn under the doctor. The cotton embedded in the knife spaces and already carried past the first roller is thrown out, and the fibres coming immediately in contact with

the leather roller A are stripped from the seed in the usual manner. The position of the two doctor knives, one above and the other below, indicates the two deliveries of the machine. The two leather rollers and the doctor blades D are each
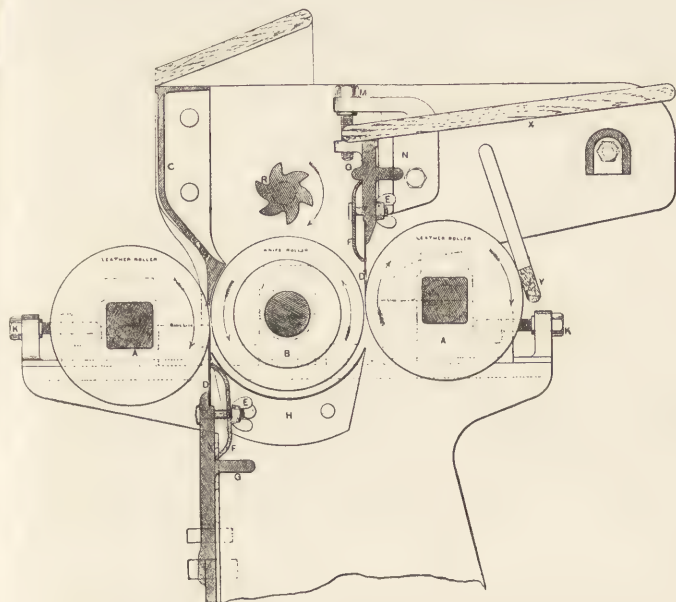
FIG. 45.— SECTIONAL ELEVATION OF DOBSON AND ROSCOE'S GIN.

capable of adjustment, and can be set up or down as desired. The production of this machine is about 33 per cent. more than that of the single roller gin.

The Saw Gin.—The saw gin is an American invention that has been in use for upwards of a century, and is still almost exclusively used in that country. The saw rollers A A are each constructed by stringing a number of steel circular saws upon a shaft. The discs are kept a short distance apart by washers of such a thickness as to allow the bars B of the

inclined grid to pass between, as shown in fig. 46. The rollers
run in the same direction, and the saw teeth pull the fibres
through the slits and leave the seeds behind. The saws are
stripped on the other side of the grid by the rapidly revolving
brush c, which throws the ginned cotton forward into the
receptacle provided for it, this being aided by the strong
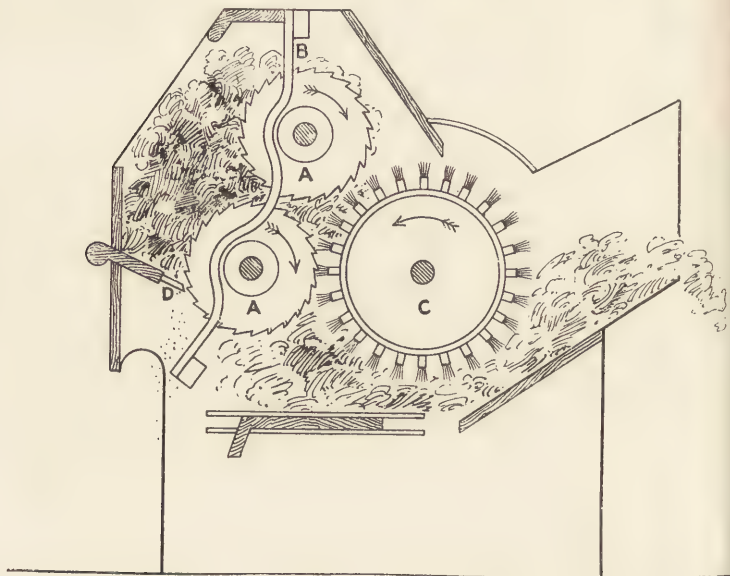
FIG. 46.—AMERICAN SAW GIN.

current of air generated in the chamber. The seeds, being
unable to pass from the feeding box in the same way as the
fibres, are thoroughly stripped, and fall to the floor through
narrow slots formed in the plate D. These slots are so
arranged that only the fully stripped seeds can pass through,
and thus the seeds which have cotton still adhering to them

are retained.   The saw gin cleans the cotton with great rapidity, the production being as much as 100 lbs. per hour, but it is only economical and effective for short cotton, like the American classes, as, if long-stapled cottons are ginned by it, the necessary small distances between the saws would allow two or more to lay hold of the same fibre.

CHAPTER VIII

The Bale Breaker.—Cotton, before exportation, s very heavily compressed into bales, as previously described in Chapter V., sometimes by steam and sometimes by hydraulic power. The only object in this procedure is to reduce the bulk of the material, so as to transport it economically. Egyptian cotton is the hardest pressed. The fibre suffers somewhat in consequence, because of the work required to properly reopen the cotton again. The machine employed in the mill to reopen the material and prepare it for cleaning and working is called a 'bale breaker.' As a matter of fact, the bales are opened by hand, and large handfuls of the hard, lumpy mass are placed on the feeding apron or lattice of the balebreaker, so that the office of the machine is really that of cotton pulling.

The bale breaker is shown in fig. 47. It has four pairs of rollers, speeded so as to produce a certain draft.

The first pair are covered with coarsely pitched spikes, the second consist of a spiked and a fluted one, the third are made up of a spiked and a fluted one, while the fourth or delivering pair are both fluted. The bottom rollers in the second and third pair are the spiked ones, but the pitch of the spikes or teeth is finer than that of the spikes in the front rollers. The top rollers are weighted by means of spiral springs, which allow them to yield when any extra hard lump is presented, and so avoid damage to the spikes. The latter do sometimes get damaged or broken by hard or foreign substances, and for this reason

the first two or three rollers are specially constructed. They
are made up of a number of discs threaded on the shaft, so
that if one gets broken it can be easily removed and a fresh
disc put on the end. The draft of a bale breaker means the
proportional enlargement in bulk of the cotton. As the
various pairs of rollers revolve at an increasing speed, it
follows that the cotton will be opened or loosened to a cor-
responding extent. The 'draft' introduced varies more in
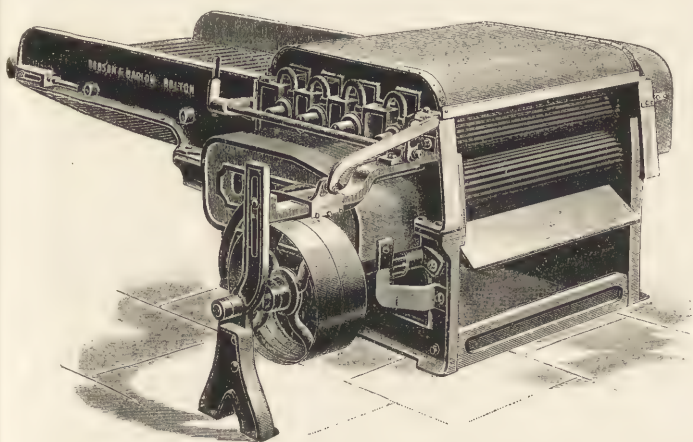
FIG. 47.—BALE BREAKER, OR COTTON OPENER.

the bale breaker than any other machine. Some prefer to
allow only just such a draft as will reproduce the condition of
the cotton before it was pressed into bales, but most spinners
adopt a large draft, say 20 or 30. It is advantageous to get
the cotton into a free, loose condition as early as possible,
and as the many types of cotton are variable in character it
follows that no one method will be suitable for all.

Messrs. Dobson and Barlow, Limited, also make the
bale breaker with a series of weighted pedals (fig. 48), and

then there is only one roller instead of the first pair. The use
of the pedal is to prevent cotton passing through unopened.
It is plain that if a lump raises one end of a weighted roller
there is an open space created, which extends almost the whole
length of the rollers. With the arrangement shown in fig 48,
that pedal only is affected which is depressed, and several
lumps may be presented simultaneously, and the whole
properly treated.
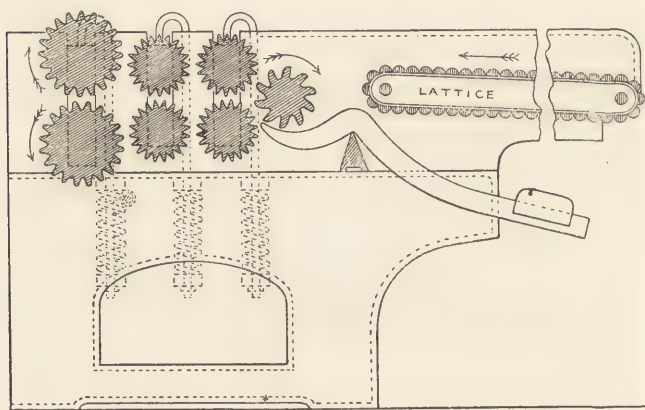
FIG. 48.—SECTION OF BALE BREAKER WITH WEIGHTED PEDALS.

The bale breaker shown in section and plan in fig. 49
is used as a 'spreader' as well as an opener.

In this case the cotton is carried from the delivery lattice
upwards by means of a 'double elevator' driven in the direc-
tion of the arrows, *see* B B in section, fig. 49. The horizontal
lattices are carried by brackets suspended from the ceiling, and
each section can be driven in either direction according to the
position of the mixing which is being fed. The cotton, after
passing through the four pairs of rollers in the machine, is
dropped upon the short apron A and carried within range of the
upright lattices B B, which are arranged so as to carry the material

upwards and deliver it upon the horizontal lattices c. These can be driven so as to drop the cotton on to either of the cross lattices D D. These are also reversible, and can deliver in
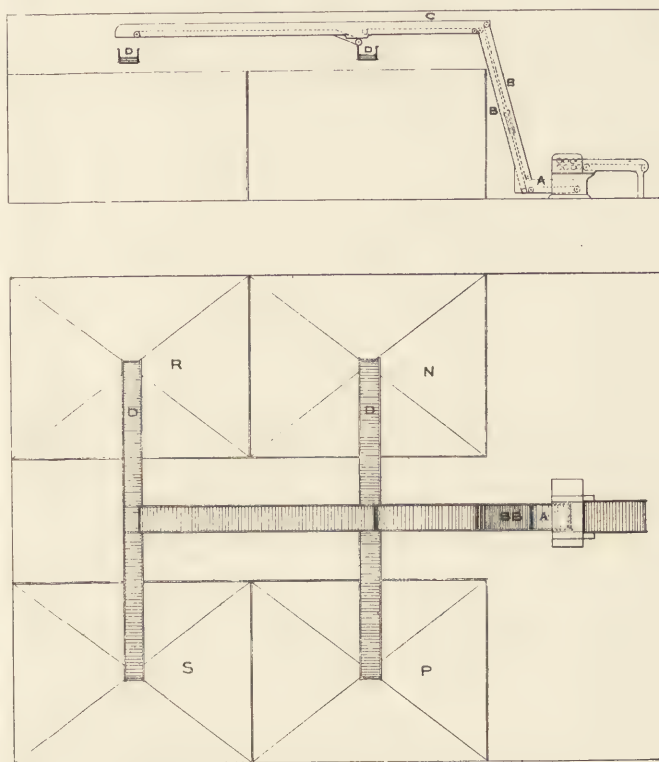
FIG. 49.—SECTION AND PLAN OF 'SPREADER' BALE BREAKER.

turns into the bins N, P, R, and s. The adoption of these spreaders means a saving of much hand labour, as all the carrying formerly done by hand is performed automatically.

CHAPTER IX

Cotton Mixing.—Mixing is a part of the process in
every mill.   It does not mean simply the mixing up of various
classifications or varieties of cotton, for mixing is just as
necessary if only one growth of cotton is used.

Irregularities of growth and staple exist in every bale.   The
cotton may be collected at different times, or the grading or
classification may be imperfect, for a ginning house often
purchases from all the plantations in the neighbourhood, and,
after ginning the cotton, bales it, and marks each bale accord-
ing to the estimate formed of its quality.

In mixing different classes of cotton, equal staple, price,
colour, and spinning qualities are to be considered.   A harsh,
wiry fibre, and a soft, pliable one cannot be mixed together, as
the treatment for the one is different from that required by the
other.   This is why some cottons are weft cottons and others
are warp or 'twist' cottons, so that, although two staples may
be of the same length, the mixing may be altogether unsuitable.
It is essential to consider the price of the cottons mixed, so as
to arrive at an average value.   A careful buyer can select
cottons of such prices as will enable him to produce a thread
of the desired quality and leave him a very fair profit.   Of
course he considers all the other points.

Cottons of different colours are not usually mixed.   If a
white thread is wanted coloured cottons are avoided.   The
colour of a mixing might also be affected by the use of the
cotton, whether it be intended for twist or weft.

Twist or warp mixings may be of a darker colour, because the yarn produced is darker, owing to the increased twist, warp yarns being 'harded twisted.'

The cotton having been passed through the bale breaker and deposited in the various mixings, is ready for the scutching room machinery. This commonly comprises openers and scutchers, as hereinafter described, but there are one or two auxiliary machines used when necessary. The latest important
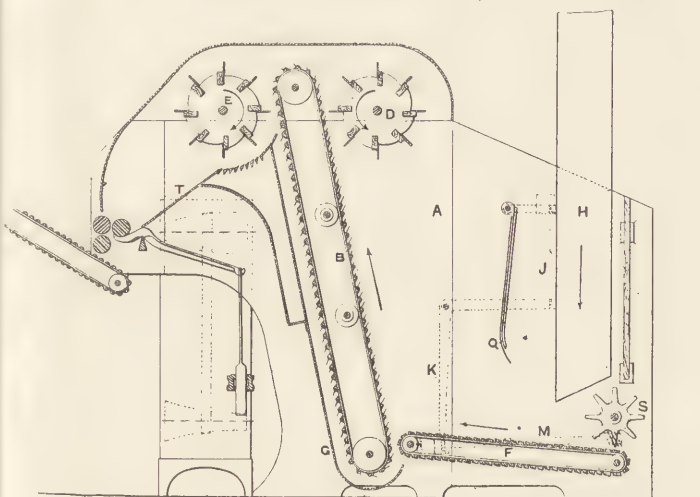
FIG. 50.—SECTION OF 'HOPPER FEEDER' BY DOBSON AND BARLOW

addition to 'blowing' or scutching room machinery is the Hopper feeder, which dispenses with much hand labour. With the use of this machine it is possible for one person to feed four or five openers at such an uniform rate as has never been equalled by hand. The hopper shown in fig. 50 is that of Messrs. Dobson and Barlow, Limited, Bolton. It consists of a large receptacle, A, which is capable of holding cotton enough to last 15 minutes or more, according to the rate of feed, which

can be regulated as afterwards described. The travelling
lattice B consists of wood laths armed with needles, as shown
in fig. 50, to assist in carrying the material upwards. A certain
thickness only of the cotton mass is enabled to ascend to the
top of the lattice, because of the revolving evener D, which can
be set in or out to increase or decrease the width of the passage.
Having passed round the upper end of the lattice, the cotton
falls downwards, and passes the rapidly revolving stripping roller
E, which, owing to its speed, creates a strong draught uniformly
across. The eight arms of the roller or stripper E are of similar
construction to those of D, and likewise require cleaning or strip-
ping. When the cotton has passed between the stripper roller E
and the grate bars it descends the plate T to the pedal roller
and feed rollers of the opening machine. There is another
travelling apron, F, in the bottom of the machine, which, by
moving very slowly in the direction of the arrow, ensures a
good supply of cotton to B by continually carrying it towards
it. It is found that the supply does not diminish in the
machine—at least until the large box is almost empty. There
are some noticeable features about the details of the hopper
feeder. Referring to the sketch, a gap capable of receiving
cotton will be perceived at the point where it leaves the long
lattice B. This cotton is of course dropped or carried down-
wards, but, being unable to get behind the guide G, is merely
transferred by the travelling needles to the feed again. The
lattices are each fitted with tighteners, and the various revolving
parts are adjustable. The student must remember that this is
not a cleaning machine, but simply, as its name implies, a
feeder ; and consequently the first lattice, B, has a canvas
foundation, so that no droppings are possible. The driving is
usually obtained from the opener itself by means of a side shaft
from the regulator, an arrangement which provides for the
stopping of the hopper feeder when the opener knocks off at

the completion of a lap. The stripper roller E is driven from
the cylinder shaft of the opener or from the overhead counter
shaft, as is most convenient. The hopper feeder is also applicable
to breaker or spreading scutchers. Whenever it is convenient
the hopper feeder just described is furnished with a regulator
feed trunk, H, and connections. It is most economically applied
when this trunk is connected to the mixing room and filled at
intervals.

As the cotton falls down the trunk it is pushed into the
chamber A by means of a revolving swift, S. The stoppage of
S will cause the cotton to block the pipe, and this is the object
of the regulator. When the chamber becomes filled with cotton
the pressure of the latter moves the feeler bar Q towards the
trunk and puts in motion the levers J and K, thus throwing
the side shaft M out of gear and stopping S. When the chamber
is getting sufficiently empty the feeler swings back and gears
the side shaft again. It will be seen that the only part of the
apparatus requiring attention is the trunk, and so long as this
is kept well supplied with cotton the automatic hopper is
performing all that is needed.

G

CHAPTER X

The Vertical Beater Opener.—The Vertical or ' Crigh-
ton's ' opener has, as the name implies, an upright ' cylinder,' or
(more correctly) beater, as shown in fig. 51. This cylinder or
beater, B, is of conical shape, the end with the largest diameter
being at the top. It consists of a number of arms, A, each
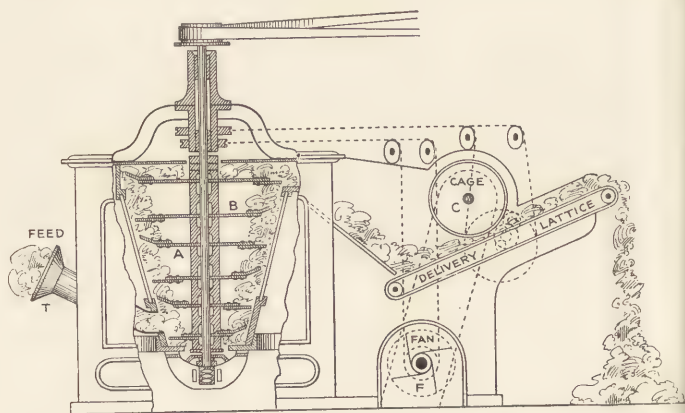
FIG. 51.— SECTION OF THE VERTICAL OR ' CRIGHTON ' COTTON OPENER

furnished with a striking blade, and is surrounded by perforated
grids. The cotton is fed by means of the feed trunk T to the
bottom of the cylinder, and, owing to the diameter of the beater
being increased (thus making the surface speed of the large
end greater than that of the small end), the material is rapidly
sucked upwards. During its passage it is violently thrown
against the grids and well beaten or loosened. The dirt and

other foreign impurities are thus thrown out, and the cotton, on reaching the upper portion of the chamber, is subjected to the action of the fan F, which draws it forward towards a cage, C. Passing under the cage, it is carried by the delivery lattice as shown, and usually delivered on to the floor in a heap. This opener possesses many advantages which make it especially effective for Indian and the lower American cottons. The former variety in particular is generally very dirty, and very hard packed in the bales.

The horizontal blow delivered by the arms of a vertical beater is most efficient, as it beats the dirt out in such a manner that it cannot return into the cotton. In using a horizontal cylinder the impurities are apt to return several times before they get clear of the cotton.

Indian cotton is generally very lumpy and solid when fed to the opener. The lumps are unable to rise readily in the cylinder because of their weight. They are consequently carried round the lower portion a greater number of times than light, loose cotton would be, and gradually opened sufficiently to ascend to the top.

In vertical machines, again, there are no feed rollers, so that the risk of fire is very small. There are several makes of the vertical openers in use, but the principal features of each are similar.

A double opener has a second cylinder similar to the one in a single machine. The first cylinder, instead of delivering to the lattice, delivers to the bottom of the second cylinder (*see* fig. 52). The cotton then ascends the second cylinder, goes forward on to the lattice, and thence to the floor. A double machine is always used for Indian cotton, because of the additional power required.

A common speed of cylinder for the vertical machine is 1,000 revolutions per minute. The bottom end of the

cone is 18″ diameter, the upper end is 2′ 9″. The speed at the bottom is thus 4,500 feet per minute, that at the top being 8,500 feet per minute. Thus is caused the partial vacuum
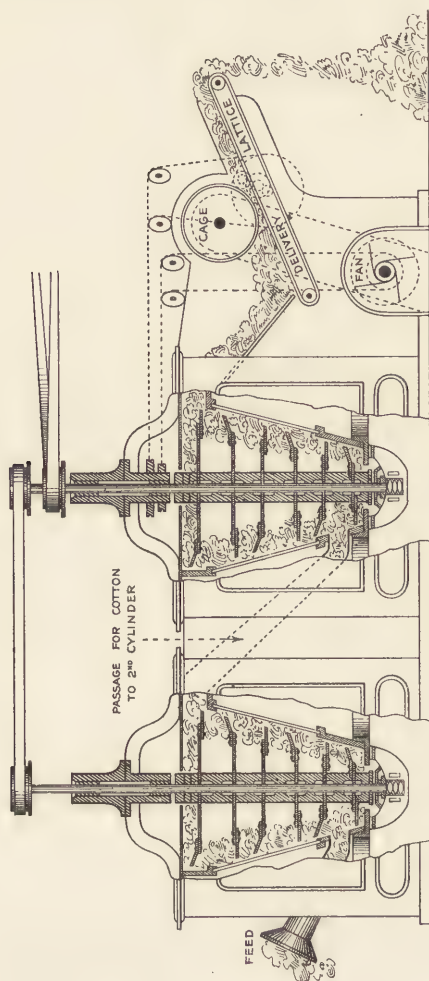

FIG. 52.—SECTION OF DOUBLE VERTICAL COTTON OPENER.

which is so effectual in exhausting the air and drawing the cotton upwards.

The production of a vertical opener is from 35,000 to 40,000 lbs. per week of $56\frac{1}{2}$ hours.

Lord's 'Exhaust' Opener.—This opener is similar to the one just described in having an upright conical cylinder (*see* fig. 53). But it is fitted with powerful fans, which, by exhausting the air inside the cylinder, can draw the cotton to the machine from a considerable distance away. This is a very important point, for the following reason : The mixing room is generally separated from the scutching room by a wall or by a floor. Suppose the mixing room to be placed above the scutching room, as shown in fig. 53.

The small machine there represented is a Porcupine feeder, which delivers into a tube, as shown. The cotton at this stage is simply loosened. It contains dust and other foreign matter which it is undesirable to bring to the cylinder. The tube is fitted with two, three, four, or more dust trunks, usually about four feet long. One of these is shown at A, fig. 53. It has a false bottom like a grid, which enables the cotton as it is sucked along the tube by the exhaust fan to deposit the dirt and loose substances it contains. If the mixing room be separated from the scutching room by a wall only the trunks are used just the same.

The material can be carried to the machine by suction a distance of a hundred and fifty or two hundred yards. It is fed to the cylinder by the pipe H (fig. 53), being admitted by flap valves, G. Ascending the cylinder, it is rapidly drawn downwards through the fan and deposited on to grids, where the cleaning process is continued. Thence it passes through the first pair of cages, the scutching beater, and the second pair of cages. It is then received by the calender rollers and formed into a lap. The mouth of the conducting pipe H may

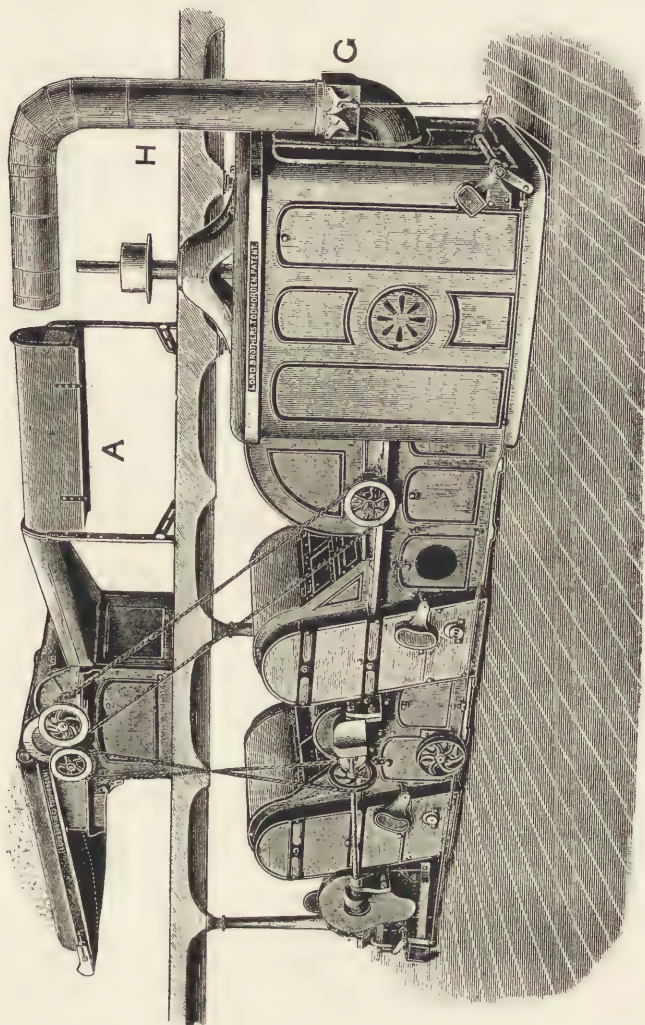be placed either at the end, as shown, or on one side of the
vertical cylinder.

Fig. 53.—Lord's ' Exhaust · Opener
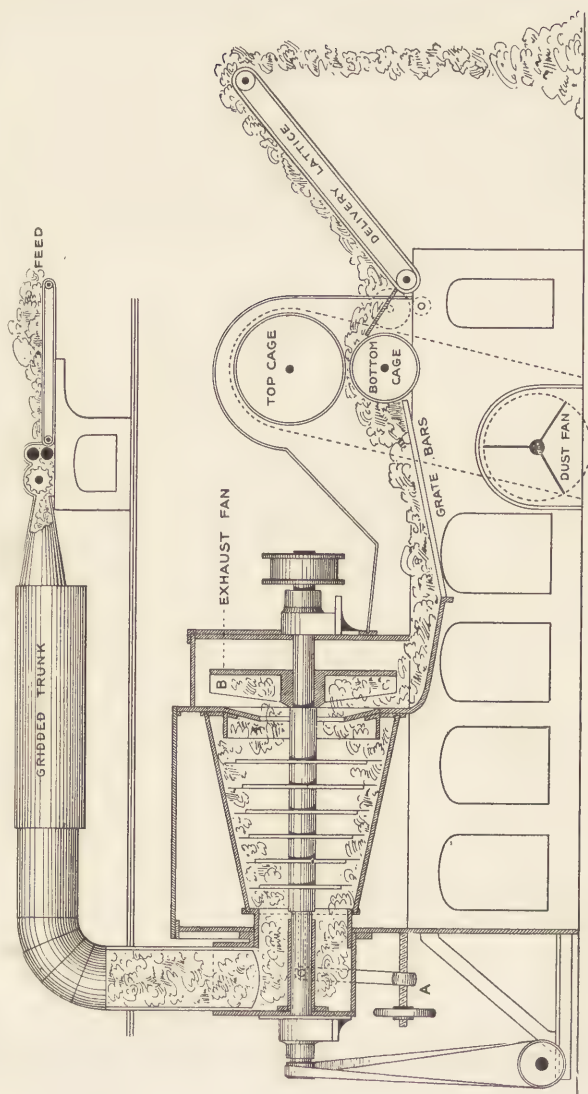
FIG. 54.—SECTION OF 'EXHAUST HORZONTAL OPENER' FOR FINER COTTONS

The vertical cylinder exhaust opener is generally used for Indian cottons, but for finer cottons another form of the exhaust opener is used. This is represented in section in fig. 54. The conical cylinder is laid horizontally, and the distance between it and the grate bars can be easily adjusted by turning a screw, A. The exhaust fan B is on the large end of the cylinder. This illustration is that of an opener without a lap part attached, and consequently delivers in a loose fleece on to the floor.

Dobson and Barlow's Opener.—This opener, which is made both single and double, the single having a cylinder and one pair of cages, and the double consisting of cylinder, beater, and two pairs of cages, as shown in fig. 55, is probably the most suitable opener for Egyptian cottons.

The cylinder in this machine is 37″ diameter, and is armed with about twelve rows of teeth, so arranged that those of one row cover the spaces of the next. The cotton is fed by being thrown upon the travelling lattice, or, what is much better, by means of the hopper feeder previously described. The regulating motion is attached, the pedals resting on a knife-edged V-rail, which, on account of the smallness of the friction, is preferable to a round shaft, as used in some openers. The inside of the cover G has ribs and spikes, against which the cotton is beaten when taken round in the direction of the arrow. After passing these the grate bars J are reached. The spaces vary, gradually becoming finer, until the cotton comes near the cages K, L. The draught caused by the fan M now rapidly draws the cotton on to the first pair of cages, and the sheet, being compressed by the delivery rollers, crosses the plate shown, and is fed to the beater, which strikes the cotton down against the next series of grate bars, Q. Cotton is delivered evener from the beater than from the cylinder. The material is prevented from being
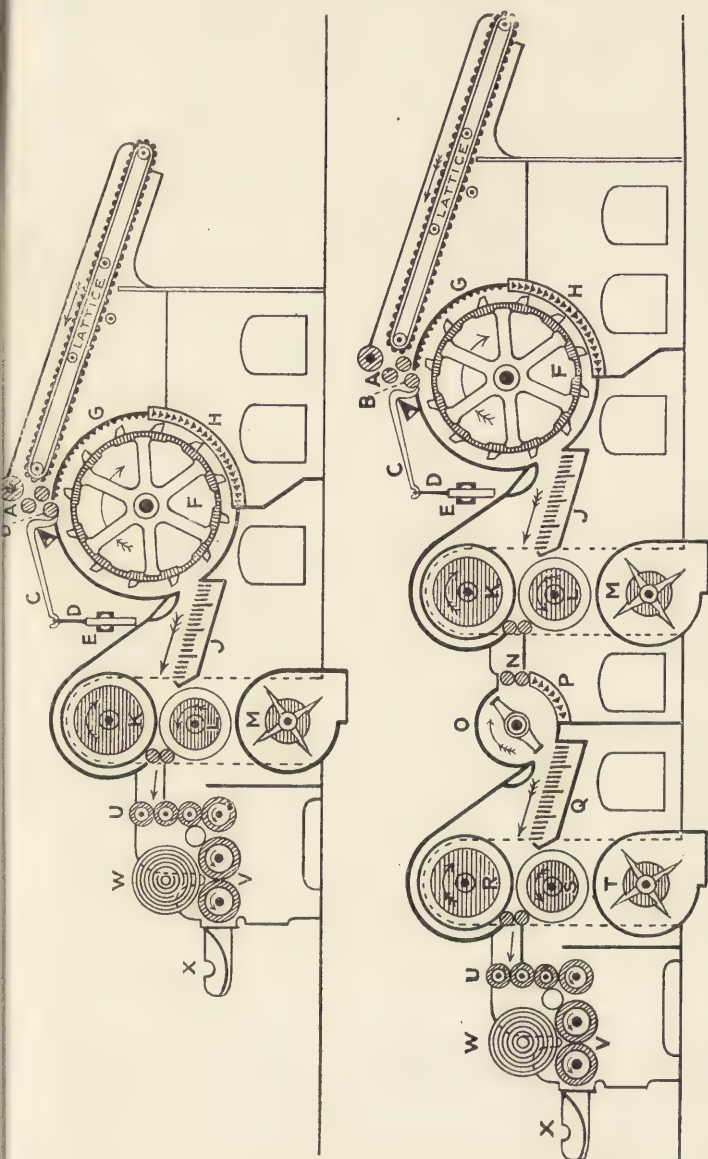
Fig. 55.—Sections of Single and Double Opener by Dobson and Barlow.

A. First feed rollers; B. Pedal roller; C. Pedal; D. Pedal pendant; E. Bowl rail; F. Porcupine cylinder; G. Cylinder cover plates; H. Cylinder dust plates; J. Transverse dust bars; K. Top cage; L. Bottom cage; M. Dust fan; N. Beater feed rollers; O. Beater cover; P. Beater dust bars; Q. Beater dust box bars; R. Second top cage; S. Second bottom cage; T. Second dust fan; U. Calender roller; V. Fluted lap rollers; W. Lap; X. Lap rest.

carried round the beater again (which would cause 'roping') by means of a stripping rail extending across the machine and fixed above the last series of bars. The fan T and the cages now form the sheet again, and as it emerges from the cage delivery rollers it is taken by the consolidating or calendering rollers of the lap part. The lap part is always put to this opener, as the sooner Egyptian cotton is formed into a lap the sooner an even lap, and consequently an even sliver, is attained.

CHAPTER XI

The Scutching Machine.—The Scutching machine is, in its objects, almost identical with the opener, but it has no cylinder, like that machine. On the other hand, it has always a ' lap part ' attached. The ' scutcher,' as it is shortly called, is intended to provide means whereby the removal of impurities is still further accomplished, and for the production of even laps. The machine is illustrated in fig. 56, and will be seen to consist of feed lattice, beater, cages, and lap machine, and in this form it is called a single scutcher. A double scutcher has two beaters and two pairs of cages.

The scutcher is usually fed from laps, but sometimes in the same way as a horizontal opener. If fed by laps from the opener the rods passed through their centres are placed in the slots s in the side framing f, and are unrolled by the lattice apron. Three or four laps are in this way ' doubled,' and the irregularities of weight or thickness are diminished. The end of this combined lap is passed between a weighted pedal roller and the nose of a pedal which forms part of the feed regulating motion, and comes within range of the beater blades, by which it is struck down. This action strikes the cotton into tufts, and flings them upon the grid i under the beater. Leaving the path of the beater, the cotton is conveyed to the dust cages, and, passing through, is rolled into a lap.

The beater h consists of solid arms forged in one with the boss and firmly fixed on a stout shaft. On the ends of the arms are secured blades of a special section, each blade reach-

Cotton Spinning

ing the whole length of the beater. There may be two, three, or even six blades to the beater, according to requirements or
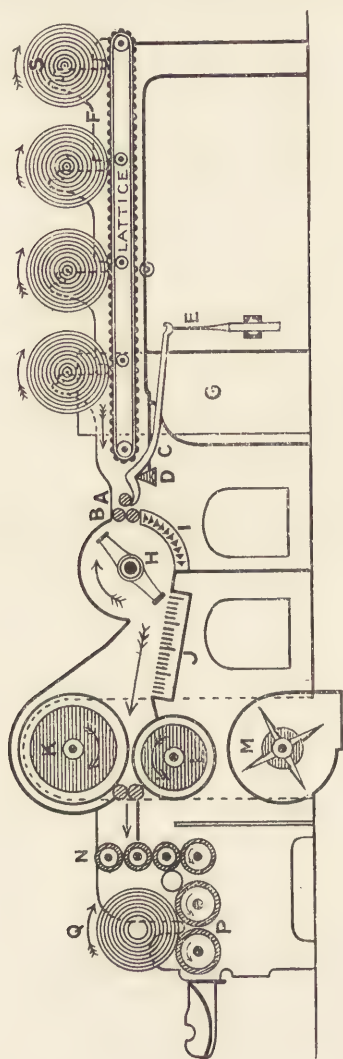

FIG. 56.—SECTION OF A SCUTCHING MACHINE.

A. Pedal roller; B. Feed roller; C. Pedal; D. Knife rail; E. Pendants; F. Side frame; G. Cone box; H. Beater; I. Grid; J. Second grid; K. Cage; L. Cage; M. Fan; N. Calender rollers; P. Lap rollers; Q. Finished Lap; S. Slots in frame for holding the laps.

difference of opinion, but the particular shape is adopted in order to present a sharp edge to the fibre. The beater is very carefully balanced before leaving the maker's hands, so as to prevent any vibration during work, when it is running over 1,000 revolutions per minute. The cages are drums made of perforated sheet zinc, and are connected at the ends to upright dust chambers called chimneys, from which the dust, after being sucked through the perforations of the revolving cages by the action of the fan M, is exhausted by the same means. It is important that the ends of the cages should fit, so as to avoid the possibility of air being drawn out between the cages and the framing. To prevent this the framing is sometimes recessed to admit the cage ends.

The dust and dirt are carried away from the machine by the fan into a flue beneath. This flue, which is about two feet square, communicates with a cellar under ground, and is conducted away thence to the open air by means of the dust chimney. The direction of motion of the fan depends on whether the flue runs along under the lap end or in the direction of the feed. Fig. 57 is a plan and sectional elevation of a scutching room, containing openers and scutchers, and showing the arrangement of flues and dust chimney. The speed of the fan is a very important item in the successful working of openers and scutchers. If the speed be excessive the power will be too great, and the cotton will not be spread on the cages properly, but will stick in the holes, and wind so roughly on the lap as to cause it to lick when placed behind the next scutcher, or the carding engine, as the case may be. Too great a fan speed will also draw the material so rapidly from the beater to the cages as not to clean it, the dirt not having had time to fall out. The air beneath the grids at this point aids the fall of the dirt materially, and so it is usual to leave an inlet for air at the ends of the beater case. This air is formed
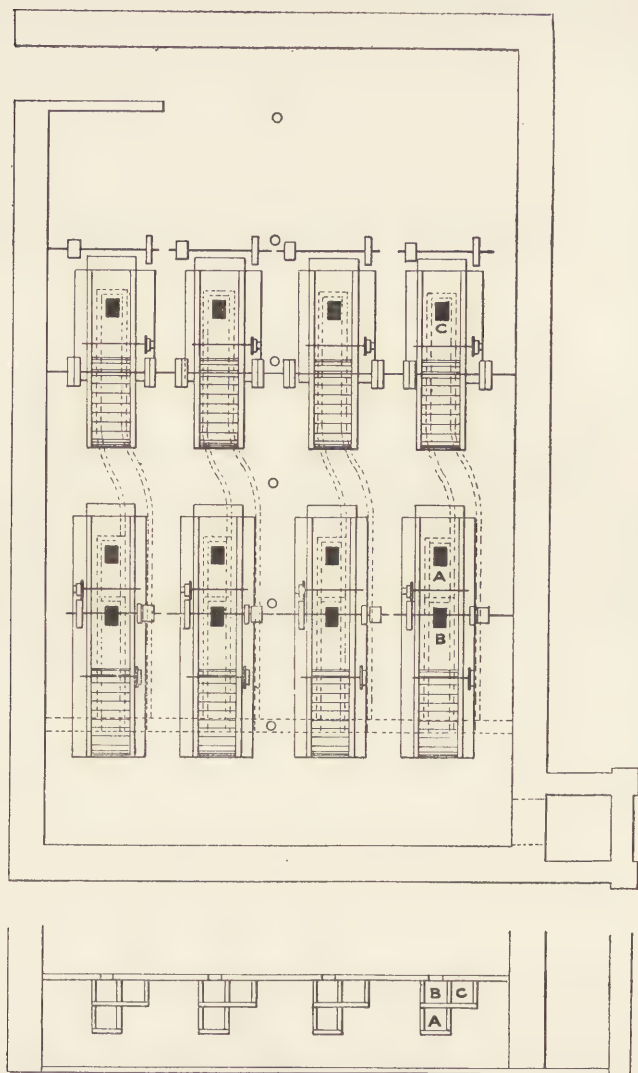
FIG. 57.—PLAN OF THE SCUTCHING ROOM, SHOWING A GOOD ARRANGEMENT
OF FLUES

into a current by the rotation of the beater. Too slow a speed of the fan will have the opposite effect—too little cleaning power and too loose a sheet. The proper regulation of the fan draught is only found by experience, but what is needed is that just sufficient suction be set up to attach the cotton to the cages. Large fans at a slow velocity are much preferable to small fans at a greater velocity. The fan draughts in the cages are adjusted by means of dampers placed at the ends, and the draught can be regulated so that the suction is principally through the top cage, as, if the draught be equally distributed on the surfaces of the two cages, it will cause the attachment to be equal on each, and the lap, on being unrolled in the succeeding process, is liable to divide and split.

Regulating Motion.—Perhaps the most ingenious portion of a scutching machine is the *regulating motion*, the object of which is to ensure, as far as possible, an uniform rate of feed to the beater. This motion is illustrated in fig. 58. The pedal roller A revolves in the curved portion of the pedal nose B. The pedals, loosely supported on a **V**-rail, as shown, have pendants, c, hung on the tail ends. The knife-edged rail extends across the machine, and supports twenty or thirty pedals close up to each other. The lower ends of the pendants widen out slightly, and pass through a frame, D. This frame has a groove in which a series of bars bearing friction bowls between each pendant slide easily. The last pendant E (see fig. 58a), has a slot coupled to the first of a series of levers connected to sectors s (fig. 58), which control the movements of the strap upon the cone-drums F F. The top cone is driven by the bottom one from a side shaft, and has on its axis a worm, H, gearing with the worm-wheel J, which with another wheel (shown in fig. 62) acts as a compound carrier driving a wheel on the pedal roller. Any movement, therefore, of the strap along the cones in either direction causes a corresponding increase or

FIG. 58.—ELEVATION OF CONE BOX AND PLAN OF PEDALS AND BOWL BOX.
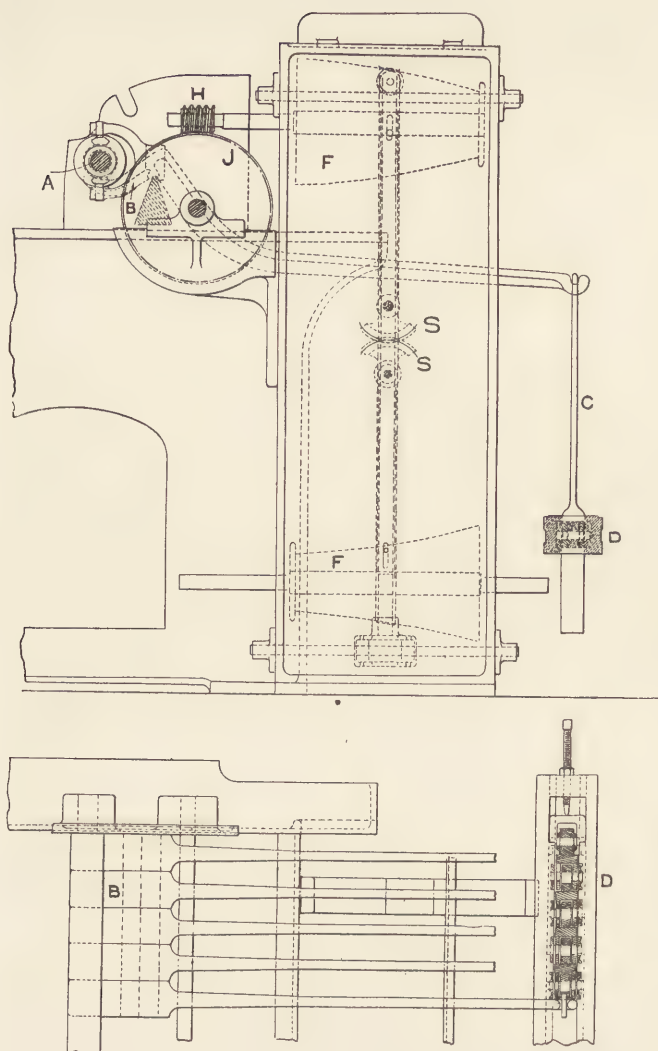
decrease in the speed of the pedal roller. The use of this contrivance is to correct irregularities in the feeding. Suppose a thick place in the lap passes between the pedal roller
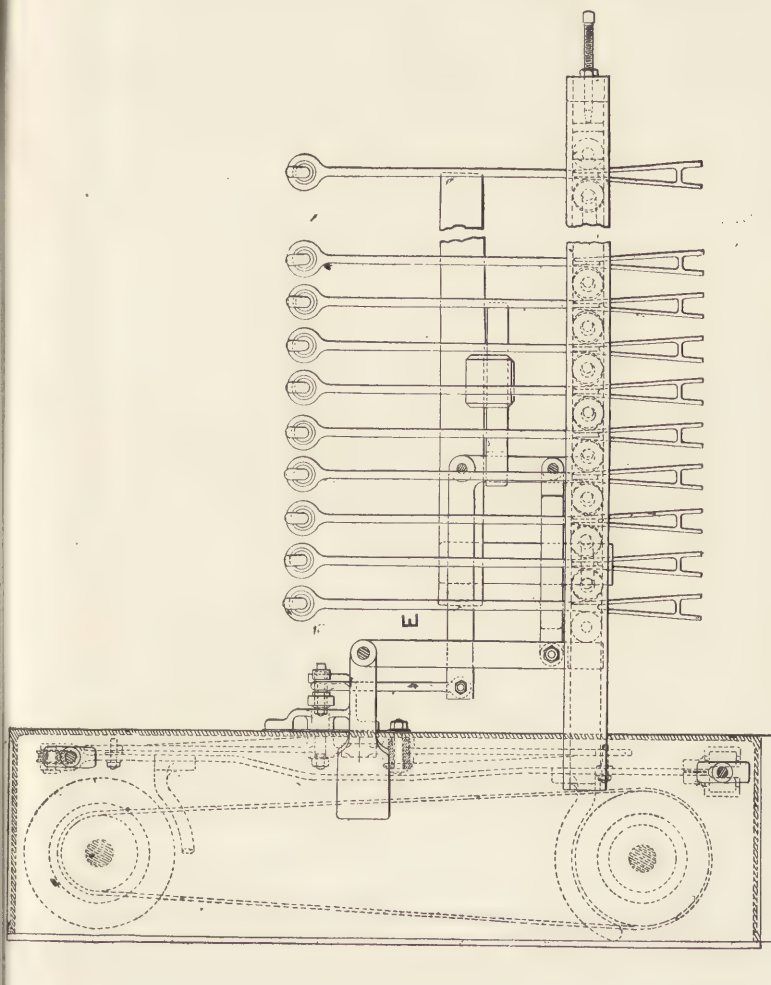
FIG. 58a.—CROSS SECTION, SHOWING POSITION OF CONES IN SCUTCHER AND PENDANTS.

and the pedal nose ; the pedal roller, being weighted, does not yield, and so the nose of the pedal is depressed, the pendant lever rises, and the expanded portion at the bottom, being unable to pass between the bowls on each side of it, exerts a pressure sufficient to move the bars holding the bowls, and causes the whole series to swing in one direction. This movement, of course, is at once communicated to the strap driving the upper cone, and the pedal roller is slowed. This allows the thick portion of the lap to be disposed of gradually. In the event of a thin place occurring in the lap the pedal presses upward, the pendant moves downward, the reverse action occurs, and the pedal roller is slightly speeded. The constant moving up and down of the pendant levers when the machine is working gives one the idea of a keyboard, and accounts for the common name given to this regulator—the 'piano' motion. The roller over the pedals of openers and scutchers is fluted longitudinally, but very commonly a pair of feed rollers is placed between this and the beater, for several reasons. The usual pedal nose, being formed by a small curve, is considered to be only suitable for short cottons, while for longer staples a specially rounded nose is used, in order that the cotton, when caught by the beater, may be struck from a less acute surface. This seems feasible, seeing that a long fibre would be liable to injury, or even complete rupture, if torn violently away by the beater blade. When double feed rollers are used as well as pedal and feed roller the tuft is struck from the circumference of the bottom one, which provides the necessary gentle curve, though many machines have the pedal nose so shaped as to make duplicate rollers dispensable. There is another advantage gained by the employment of double rollers. When the piano motion is acting on a thick piece of lap the pedal roller slows, and meanwhile the beater must be beating out a thinner plate in the already fed material. As the velocity of the

single pedal roller is constantly changing by reason of the
irregularities of the lap, so the uniformity of the beaten cotton
must vary correspondingly. By giving a certain regular speed
to the duplicate feed rollers, and that speed being equal to the
average speed of the first roller, this difficulty is almost sur-
mounted. The second pair of rollers is fluted both longi-
tudinally and circumferentially. The setting of the grate bars
under the beater is one of the details to be attended to in the
scutcher. They should be placed so as not to receive the
fibres straight on the sharp upper edge, but more on the side,
thus giving a face blow and shaking out more dust. Again, a
wider space should be left between the path of the beater and
the bars at the delivering than at the receiving end of the series,
as the cotton obviously increases in bulk through being opened.
On the whole, the bars should be set more closely than in the
case of the beater of an opener, as most of the heavy impurities
have already been abstracted. The two-winged or two-bladed
beater is usually preferable to the three-winged one. It is
smaller in diameter, being about 14″, and is more easily
and accurately balanced, and can be run without vibration at
a much higher speed. The three-bladed beater, which is
generally 16″ or 18″ in diameter, is revolved at a slower rate,
and gives a more dragging blow. It is desirable that a very
sharp blow should be given, so that the blade leaves the cotton
quickly. The lap roller, upon which the cotton is wound, is
driven by friction from the two shell rollers, and a 'knocking
off motion' is fitted for the purpose of stopping the calender
rollers at a given moment—that is, when the lap is full. The
pinion R on the drop shaft (*see* fig. 59) engages with the
wheel on the bottom calender roller, and as soon as the required
length of lap is made the tumbler T on the ratchet wheel dis-
places the catch L and allows the lever M to fall. This causes
the pinion R to fall out of gear, and the calender rollers are

stopped. It will be seen by a reference to the same elevation that the pedal roller is fitted with a catch-box. When the handle lever M falls at the completion of a lap its inside tail-piece (*see* fig. 59), connected as shown to the upright shaft s, turns the latter a short distance. This upright carries a fork, F, engaging with the catch-box in the usual manner, and when the motion takes place the pedal feed roller is at once stopped by the driven half of the catch-box being thrown out of gear, thus stopping the feed.
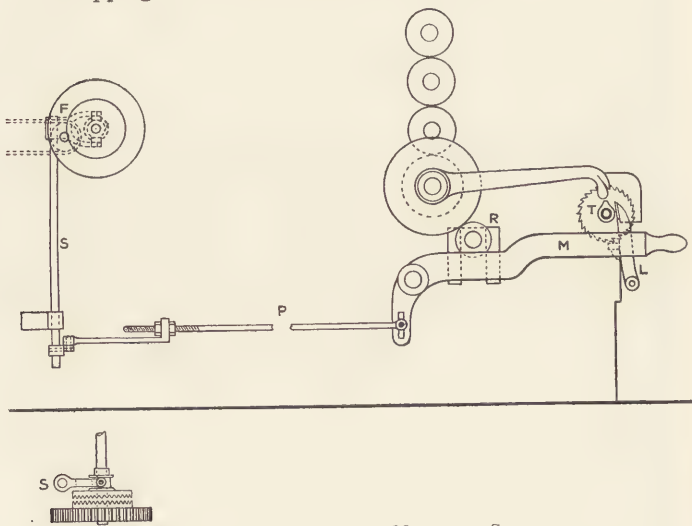
FIG. 59.—ELEVATION OF STOP MOTION IN SCUTCHER.

The lap roller is bored so as to hold a rod called a lap rod, which is made of wrought iron, and it has a large cast-iron flange upon one end for a head. When the machine stops and the lap roller is withdrawn ready to commence the next lap the rod remains in the lap, being held by the flange, which is larger in diameter than the hole left by the lap roller. The lap is then handled without any danger of the central hole

being closed up, which event would cause 'stabbing' when in-
serting a rod afterwards at the next machine.

All the ordinary essentials of the scutching machine have
now been mentioned, but many parts have been improved or
modified since the machine assumed its present general form.
For instance, the use of two or three bowls between each pair
of pendant levers in the 'piano' regulator is becoming almost
universal. The object of this practice is to reduce the amount
of friction set up when more than one pedal is acting. It is
obvious that when two adjacent pendants rise at once they tend
to turn the single bowl between them both ways, and such a
friction results as to prevent the motion acting at all. In the
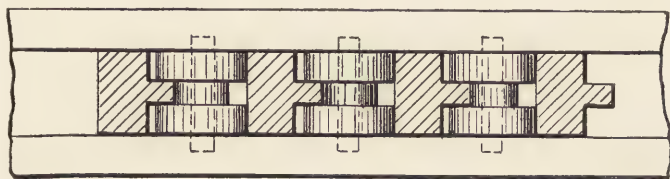
FIG. 60.—PLAN OF HOWARD AND BULLOUGH'S BOWL ARRANGEMENT.

three-bowl arrangement of Howard and Bullough (fig. 60) the
pendants are each cast with a small rib on one side, which en-
gages with the small bowl as shown, and when two or more rise
simultaneously it is impossible for them to oppose each other,
as in the old arrangement.

The driving of the various parts of the scutching machine
is obtained from the beater shaft, which derives its motion
from the overhead counter-shaft. (*See* fig. 57—Plan of Room.)
In a double scutcher both beaters are driven from the counter
by one pulley ; in a single opener the cylinder is thus driven ;
whilst in the double opener the counter drives both the
cylinder and beater by separate pulleys. Referring to the plan
of a double opener (fig. 61), it will be noticed that the beater

shaft A drives the fan on one side of the machine and the lap
end driving shaft on the other. The latter shaft gives motion
to the cages, the delivery, calender, and lap rollers, and their
connections on the left side of the machine, and drives the side
shaft, regulating motion, and feed rollers on the right. The
roller drives the travelling lattice, and as all these parts depend
upon each other this arrangement enables the supply of cotton
to the machine to be stopped at the same moment as the
delivery.

In double machines one fan always drives the other, and
there are two side shafts, one driving the first pair of feed rollers
(in front of the cylinder or first beater) through the cone drums,
the other the second pair of feed rollers supplying the second
beater. No cone drums are required in the latter case, as the
speed is uniform, there being no regulator attached.

If the pulley A on the beater be changed the whole of the
speeds of the working parts of the machine are altered, and if B
be changed everything except the speed of the beater and fan will
be altered. By changing the wheel C—the draft wheel—the rate
of feed is increased or decreased without interfering with the
speed of the lap end, but, of course, the thickness of the lap
delivered, or the weight per yard, is altered. This is called
giving a draft to the machine. The time it takes to produce a
lap is also governed by the size of the pulley B.

Improved Toothed Beater.—What is known as Kirsch-
ner's Improved Toothed Beater consists of three bars carry-
ing lugs, in each of which tempered steel teeth are fixed. These
are made to vary in fineness and length according to the work
required of them. The following advantages are claimed for
this form of beater :—

1. Better cleaning properties.
2. Lap more homogeneous and regular.
3. Lap always well-made, cylindrical, and with good edges.

1 & 2 – SHELL ROLLERS   3 – CALENDER ROLLER
                                              4 7 & 9 – DELIVERY ROLLERS   11 – CYLINDER
5 & 8 – CAGES   6 – FEED ROLLER   10 – PEDAL ROLLER

BOTTOM
CALENDER ROLLER

RATCHET WHEEL
(CHANGE)

DRIVING SHAFT

DROP SHAFT

RATCHET WHEEL

FAN STRAPS

TOP CONE DRUM

BOTTOM CONE DRUM

THIS WHEEL
IS ON
THE BOTTOM CONE DRUM

STRAPS FROM COUNTER SHAFT

DROP SHAFT

DRIVING SHAFT
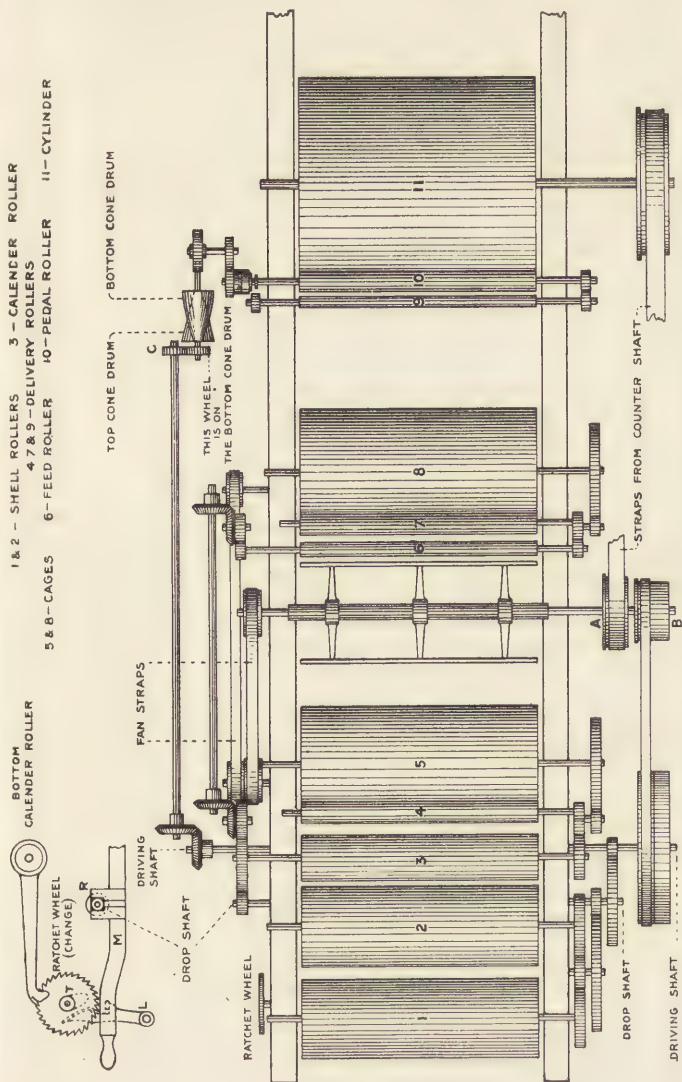
FIG. 61.—PLAN OF DOUBLE COTTON OPENER WITH 37″ PORCUPINE CYLINDER, BEATER, AND LAP PART.

4. Lap never sticking or felting behind the cards.

5. Less grinding of cards, on account of cotton being more open, parallel, and clean ; therefore less wear on the points of the wire.

6. Stronger and more elastic yarn.

Calculations on the Scutcher Machine. *Ratio and Proportion.*—A good knowledge of these is essential before students can intelligently work out the various problems given on the machine in question. It often happens that a student cannot work out a problem given in a test or in the mill because it is not expressed exactly in the form of the rule which he has been so careful to learn. In connection with the scutcher all ordinary calculations can be worked by understanding ratio and proportion.

Ratio.—Ratio is simply the relation which one quantity bears to another quantity of the same kind in respect of magnitude. In the case of the scutcher *speeds* are referred to. The ratio of A to B would be expressed like this, $A : B$.

Proportion.—If we have two ratios equal to each other, the four terms making up the two ratios taken in order are said to be *proportionals*, and when thus expressed are also said to be *in proportion*. Thus $\frac{3}{4}$ and $\frac{12}{16}$ are equal ratios, and when we say 3 : 4 as 12 : 16, and express these two ratios thus :—

$$3 : 4 :: 12 : 16,$$ we have a proportion.

By *draft* is meant the ratio in surface speed between the pedal roller and lap roller.

Now suppose the surface speed of the pedal roller be given as ·051 inch in a given time, and that of the lap roller ·228 inch in the same time. The ratio will be ·051 to ·228, which means that the latter is travelling $\dfrac{·228}{·051}$ time as fast as the former, which comes out 4·4. *This is called the draft.* This is equal to saying that a lap is given on the lap roller 4·4 times

as long as that on the feed lattice or pedal roller. In other words, one yard on the lattice comes out on the lap roller 4·4 yards long.

Fig. 62 represents the plan of a single scutcher, and gives also the elevation of the gearing at the lap end. The figures
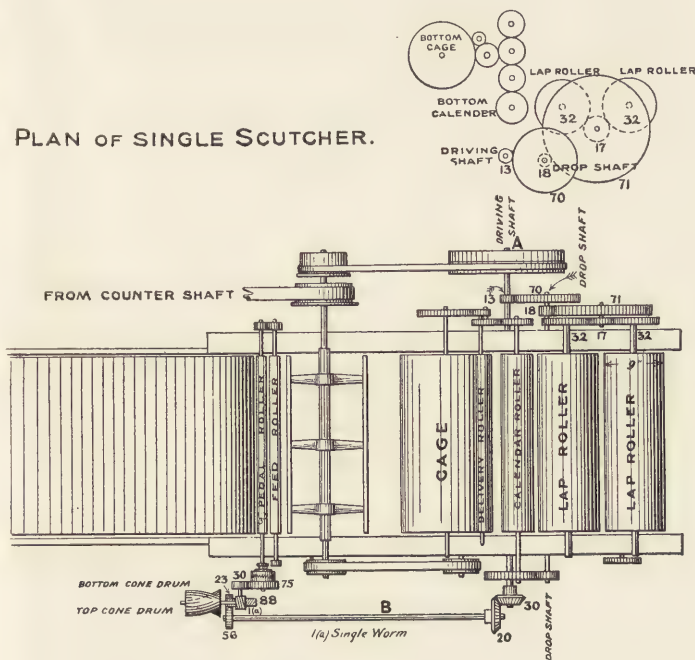

FIG. 62.—PLAN OF SINGLE SCUTCHER, ALSO SHOWING THE ELEVATION OF THE GEARING AT THE LAP END.

represent the number of teeth in the wheels and also the diameters of lap and pedal rollers. All calculations, as before stated, are made by means of ratio.

The proper method of calculating can best be illustrated by taking one or two examples.

(1) *To find the draft produced* on this machine when the speeds and wheels are given.

The speed of driving shaft A in this case is taken as one revolution per minute. On A is a wheel having 13 teeth, and this drives one having 70 teeth. Clearly, then, the ratio in speed of these two will be as 13 is to 70, or the latter runs $\frac{13}{70}$ths the speed of the former, or $\frac{13}{70}$ths of A. Using this ratio $\frac{13}{70}$ths, we find the speed of the wheel having seventy-one teeth.

Reference to the diagram shows that this wheel is driven by a compound carrier having eighteen teeth. This must have the same speed as the wheel with seventy teeth, which was found to be $\frac{13}{70}$ths of A.

A seventy-one toothed wheel is driven by the eighteen. Therefore the second ratio will be 18 : 71 ; or, in other words, the seventy-one toothed wheel is driven $\frac{18}{71}$ times the speed of the eighteen wheel, which is $\frac{13}{70}$ths of A, or $\frac{13}{70} \times \frac{18}{71}$ of 1.

The next speed to be found is that of the wheel having thirty-two teeth. This is driven by a compound carrier of seventeen teeth, and reference to the figure shows this to be driven by the seventy-one toothed wheel. Therefore the speed of the seventeen toothed wheel is as 17 : 32, or the speed of the thirty-two toothed wheel is $\frac{17}{32}$nds of the former.

This speed has been obtained as $\frac{13 \times 18}{70 \times 71}$ of 1. Therefore the speed of the lap roller must be $\frac{17}{32} \times \frac{13}{70} \times \frac{18}{71}$ of 1 = ·025.

The circumference of a roller or pulley is always equal to the diameter × by 3·1416.

The lap roller is 9″ in diameter, and its surface speed will be ·025 × 9″ × 3·1416 = ·225″ × 3·1416 per minute.

The speed of the *pedal roller* is to be found next. (Refer to fig. 62 again.) On the end of the driving shaft A is

bevelled wheel of thirty teeth. This drives a wheel having twenty teeth. Therefore the ratio in speed of the first wheel to the second wheel is as 30 is to 20, or 3 : 2. That is, the second wheel goes $\frac{3}{2}$ time as fast as the first wheel, or $1\frac{1}{2}$ time A. At the opposite end of shaft B is a wheel having fifty-six teeth. This drives one with twenty-three teeth on the bottom cone, shown in the diagram. The ratio must be then 56 : 23. Speed of latter wheel will clearly be $\frac{56}{23}$ of the fifty-six toothed wheel, which has been shown to be $\frac{3}{2}$ of A.

The speed of the wheel on the bottom cone drum will be then $\frac{3}{2} \times \frac{56}{23}$ of A, or I.

The speed of the wheel with eighty-eight teeth is next to be found. This is driven by cone drums through a single worm, or one-tooth equivalent; the speed, then, of the worm wheel must be $\frac{1}{88}$ of that of the cone drum. This is equal to $\frac{1}{88} \times \frac{3}{2} \times \frac{56}{23}$ of I.

Now the speed of the wheel on the pedal roller is to be found. This is driven by a carrier wheel having the same speed as the worm wheel. Then the ratio of the pedal roller to this will be as 30 : 75, or the latter wheel will have a speed $\frac{30}{75}$ of $\frac{1}{88} \times \frac{3}{2} \times \frac{56}{23} \times I$. This equals ·016.

The diameter of the pedal roller is $3''$. Therefore the surface speed of the pedal roller will be ·016 × $3''$ × 3·1416 = ·048$''$ × 3·1416 per minute.

The draft was said to be the ratio in the surface speed between the pedal roller and the lap roller. The former we have found to be ·048$''$ × 3·1416 and the latter ·225$''$ × 3·1416.

Therefore the draft equals $\frac{·225 \times 3·1416}{·048 \times 3·1416} = \frac{·225}{·048}$, or 4·6.

This is the *draft* of the *scutcher machine*.

(2) *To find the speed of the beater.*—Refer to diagram (fig. 63) upon which the speeds are given. The speed of the line shaft

is always given—say in this case it is 245 revolutions per minute. The pulley on the line shaft is 32″ in diameter. This drives a 16″ pulley on the counter shaft.

The ratio, then, is 32 : 16, or 2 : 1. That is, the latter pulley, viz. the 16″, makes $245 \times \frac{2}{1}$ revolutions, or 490.

The counter shaft speed therefore is 490. To this shaft is attached a 32″ pulley, and this speed must be 490 also. This drives a 13″ pulley on the beater shaft. The speed, therefore, is
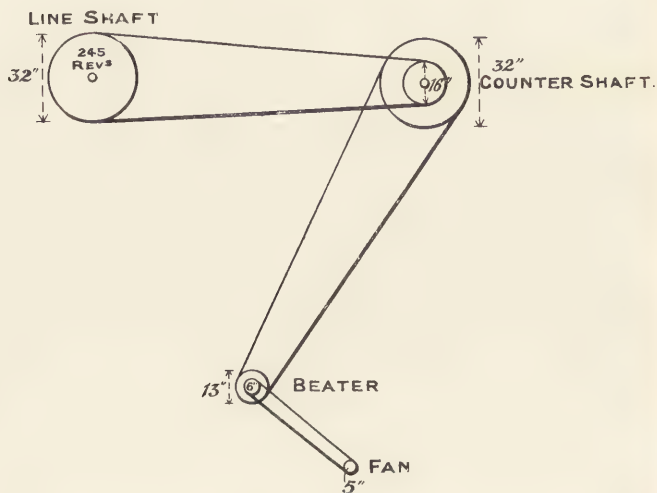
FIG. 63.—VERTICAL SECTION THROUGH THE LINE SHAFT, COUNTER SHAFT, BEATER, AND FAN.

in the ratio of 32 : 13, or $\frac{32}{13}$ of 490, or 1206 revolutions per minute. This, then, is the speed of the beater.

(3) *To find the speed of the fan.*—The beater shaft pulley, which is 6″, drives a 5″ on the end of the fan shaft. Ratio is as 6 : 5, or the fan goes $\frac{6}{5}$ of 1206, which comes out 1447 revolutions per minute.

(4) *To find the production of a scutcher machine when the speed*

of wheels, number of teeth, hours of running, diameter of calender roller, and weight of lap per yard are known.—In the example taken the numbers used will be those found on the given diagram (fig. 64).

The speed of lap end pulley = 351 revolutions per minute. Driving wheel on the driving shaft contains 13 teeth. This drives a wheel with 70, which is called the drop-shaft wheel.
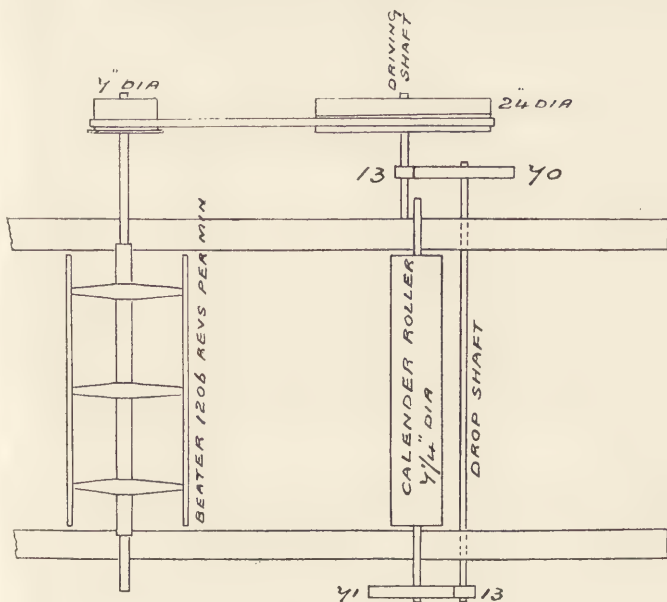
Fig. 64.—Plan showing Beater, Calender Roller, Drop Shaft, and Driving Shaft.

On the opposite end of the drop shaft is a wheel with 13 teeth. This drives on the end of the bottom calender roller a wheel with 71 teeth.

Speed of calender roller will be, as before shown by ratio,

$$\frac{351}{1} \times \frac{13}{70} \times \frac{13}{71} = 11 \cdot 9.$$

This 11·9 equals the number of revolutions of the calender roller per minute.

The diameter of the calender roller is $7\frac{1}{4}''$, and this, multiplied by 3·1416, will give the circumference of it. This equals $22·7''·$ When reduced to yards this is $\frac{22·7}{36} = ·63$ yard.

To get the yards per minute $11·9 \times ·63 = 7·497$ yards per minute delivered by the calender roller.

The weight of the lap, say, is to be 12 ozs. per yard long. Therefore, to convert this 7·497 yards into lbs. per minute delivered, multiply 7·497 by $\frac{12}{16}$, or $\frac{3}{4}$, 12 ozs. being $\frac{3}{4}$ of a lb. avoirdupois.

$$7·497 \times ·75 = 5·62275 \text{ lbs. per minute.}$$

In one hour this will be 337·365 lbs. per hour.

In a working week of $56\frac{1}{2}$ hours only 46 hours can be reckoned upon for continuous running, which gives a production of $337·365 \times 46 = 15518·79$ lbs. per week produced at the lap end of the scutcher.

(5) *To find what knocking off or ratchet wheel is required when a change is desired in the length of the lap.*—Fig. 65 gives an elevation of the bottom calender roller, ratchet wheel, and drop lever.
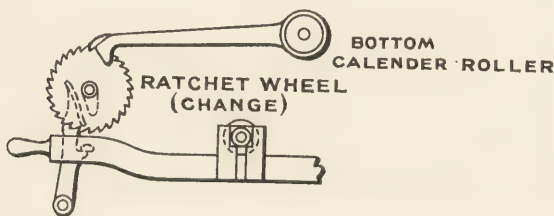
FIG. 65.—ELEVATION SHOWING BOTTOM CALENDER ROLLER, RATCHET WHEEL, AND DROP LEVER.

Say a lap of 36 yards long is desired, the diameter of the bottom calender roller is $7·25''$, and the draft between the

calender roller and lap roller is 1·1. Required to find the change or ratchet wheel.

The draft allowed above is for the simple purpose of keeping the lap tight between the rollers, and for this reason the lap roller is made to go at a slightly increased speed. This must be allowed for in working out the above calculation.

36 yards length of desired lap = 1296″.

Diameter of calender roller = 7·25″; circumference = 22·7766″.

The number of revolutions of the calender roller made in 1296″ will clearly be $\dfrac{1296''}{22\cdot7766}$.

As before pointed out, the calender roller is going a little slower than the lap roller. To bring it up to the same speed, multiply 22·7766 by the coefficient, or draft, 1·1, and as a result $\dfrac{1296''}{22\cdot7766 \times 1\cdot1}$, or 51·7 revolutions are made.

By means of the eccentric fork one tooth of the ratchet wheel equals one revolution of the bottom calender roller. Hence it follows that a ratchet wheel having 51·7 teeth, say 52, is required to obtain a lap 36 yards long.

(6) *To alter the length of lap without varying the thickness.*— To do this a change of wheel must take place.

In the last example, to get a lap 36 yards long a 52-toothed wheel was required.

Required to find wheel when a lap 40 yards long is wanted. For 36 yards a wheel having 52 teeth was used.

For 1 yard   ,,   ,, $\dfrac{52}{36}$ will be required.

For 40 yards   ,,   ,, $\dfrac{52}{36} \times 40$ will be required.

$$\frac{52 \times \overset{10}{\cancel{40}}}{\underset{9}{\cancel{36}}} = \frac{520}{9} = 57\cdot7, \text{ say 58 teeth, in the wheel required.}$$

(7) *Required to find what quantity of cotton is to be spread on a given length of the feed lattice to produce a lap of given weight per yard.*

Suppose a lap of 11 ozs. per yard is required.

First divide the feed-lattice into equal lengths. For the sake of illustration, take one of these lengths as 4′ 6″. These lengths are usually painted to distinguish the number of divisions.

The draft is given as 4, which means that the ratio in speed between the pedal and lap roller is as 1 is to 4.

As a lap of 11 ozs. is required per yard, there must be spread on the 1 yard of lattice 44 ozs., and on the $\frac{1}{2}$ yard 66 ozs., because the draft is 4.

There will be a little waste ; this is usually put down at 5 per cent., and 5 per cent. of 66 ozs. $= \frac{5}{100}$ of $\frac{66}{1}$ ozs. $= \frac{1}{20}$ of $\frac{66}{1} = \frac{66}{20} = 3\frac{3}{10}$ ozs.

To obtain this 66 ozs. in a finished lap we must add the waste which inevitably follows in working the cotton through the machine ; therefore $66 + 3\frac{3}{10} = 69\frac{3}{10}$ ozs. $=$ the weight which must be spread on the given length named above, viz. 4′ 6″.

General Rule for Drafts.—The following rule by Mr. Thornley gives in a compact form an easy method of obtaining the drafts of the various machines used in spinning operations, and especially applies where there is a connection between two points of a machine. It is good for intermediate as well as for total drafts.

Rule.—' *Taking simply the two points between which it is necessary to find the drafts, regard the wheel on the delivery roller as the driver of the feed whether it be so or not ; divide the product of all the driving wheels or pulleys and the diameter of the feed roller* **into** *the product of all the driven wheels or pulleys and the diameter of the delivery roller.*'

CHAPTER XII

Carding.—After the raw material has passed through the opening and scutching machines the fibres are found matted together or lying in different directions, and they must first as nearly as possible be placed parallel to each other before they can be spun into a thread. From their tendency to curl, repeated brushing or combing is necessary, not only to place the fibres straight, but to remove such as are short in length, as well as the neps and any other remaining impurities.

In the carding process the felted fleece, delivered by the scutcher with its fibres crossed in all directions, is combed out a great number of times, so as to straighten out the fibres ; and the light impurities, such as short fibres and bits of the moss-like coverings of the seeds, still adhering to it are taken out. These, if allowed to remain in the sliver produced by this operation, would give a roughness to the yarn.

Roller and Clearer Card.—The unlapping of the fleece is performed by the roller A on which the lap rests (*see* fig. 66), which is a sectional elevation of a roller and clearer carding engine. The fleece is then drawn forward under the feed roller B, and delivered to the licker-in C, revolving in the direction of the arrow. At this point the carding or combing action commences, the fleece being held by the feed-roller B, travelling at the slow speed of only about 9″ of surface a minute, while the licker-in C runs much faster, at about 1,000 feet per minute of surface speed ; and the teeth on the licker-in being bent forward in the direction of

motion, the points of the teeth strike down into the fleece held
by the feed-roller, and comb out the fibres, while the impurities
being separated fall to the ground.   The fibrous tufts of cotton
are carried round on the under side of the licker-in to the main
cylinder D, which revolves in the same surface direction with a
speed of about 1,600 feet per minute.   The teeth of the
cylinder, being bent forward in the direction of motion, sweep
off the cotton from the licker-in teeth inclined in the same
direction, but running at only half the speed, and carry it for-
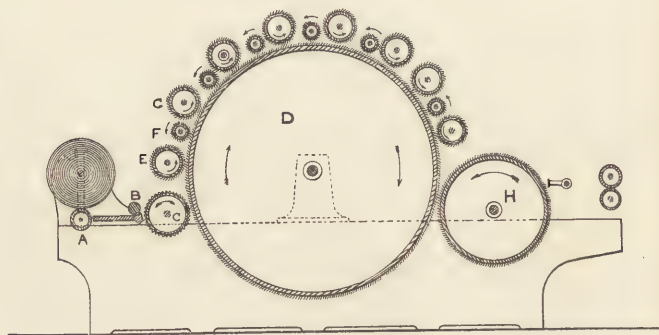
FIG. 66.—SECTION OF ROLLER AND CLEARER CARD.

A. Roller on which lap rests ; B. Feed roller ; C. Licker-in ; D. Cylinder ; E. Dirt
roller ; F. Clearer ; G. Roller.

ward to the dirt roller E, the teeth of which face those of the
main cylinder, and which travels at a very slow speed.   This roller
is automatically stripped by a comb, and its object is to take
moats and leaf and some short cotton from the main cylinder.

The main cylinder then carries the cotton forward to the
several pairs of rollers and clearers ; and at each pair in suc-
cession the fibres undergo a further combing out and straighten-
ing.   The motion of the teeth of all these pairs of rollers is in
the same direction as that of the adjacent teeth on the
main cylinder, as shown by the arrows, but at a much slower

speed ; and the teeth of the clearers F are inclined forwards in the direction of motion, while those of the rollers G are set the opposite way, so as to present the points of the teeth facing those on the main cylinder. The cotton on the main cylinder is therefore carried past the clearer F without being caught by its teeth, and is caught upon the teeth of the roller running at about 20 feet a minute, so that a combing action for straightening the fibres and dividing the tufts of cotton is obtained by the excess of speed in the main cylinder, running at the high velocity of 2,200 feet a minute. All fibres failing to pass the roller G are carried round upon its teeth to the clearer, which runs at a surface speed of about 400 feet a minute, being thus intermediate in speed between the roller G and the main cylinder D ; the teeth of the clearer therefore sweep off the cotton from the roller, and are themselves stripped in the same way by the main cylinder, running at the higher speed. After passing all the rollers and clearers, the fleece of straightened fibres is taken off in a continuous sheet from the main cylinder D by the doffer H, the teeth of which face those of the cylinder, but move at a much slower speed of from 77 to 90 feet per minute. The cotton is then carried round on the under side of the doffer to the vibrating comb. This comb strips the cotton from the face of the doffer in its down stroke, and clears itself in rising ; and the thin fleece, of the full width of the machine, is then gathered in by guides, and finally into a smooth funnel having a very small hole. The sliver is thus formed into coils which cover one another in the can, so that it is filled up solid, and when taken to the drawing frame the sliver comes out again without adhering. In fig. 67 is shown a roller and clearer card.

Carding Engine with Stationary Flats.—The action of the flat card is more efficient as regards the parallelising of the fibres than the roller card, for this reason : that the speed of

the cylinder being sufficient, the cotton is held at one end by the cylinder wire, and as soon as it comes under the influence of the first flat it is by centrifugal force thrown against the 'toe' of the flat, and on its progress, due to the revolution of the cylinder, combed down by the bevel in the flat as far as the 'heel.' This is repeated from flat to flat, the space between the flats being sufficient to allow the cotton to fly away from the cylinder by centrifugal action, so that in no part is the sur-
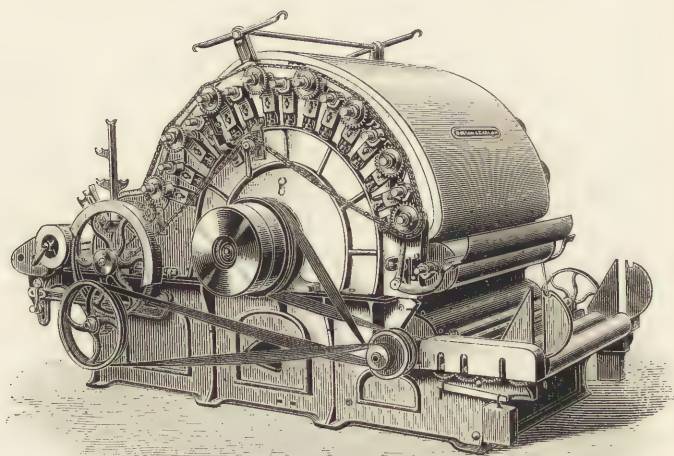
FIG. 67.—A ROLLER AND CLEARER CARDING ENGINE.

face of the flat lost, but the effect is the same for every flat. If there were no spaces between the flats, or no bevel in the setting of them, the cotton taken from the licker-in would have no chance of changing its position, operated upon as it is in all senses by the flats ; and this of course is quite necessary in order to have a clean and smooth sliver. This shows the benefit of the inclination or bevel of the flats, and also the necessity of having a space between each flat.

If the cotton is properly opened and placed upon the cylinder by the licker-in, then the action that takes place is the drawing of the cotton over the surface of the wire, and motes, neps, and short cotton are held by this. Consequently the flats require stripping at certain intervals. The action of this continued combing from the back flat to the front means that coarser wire is required at the first flat,
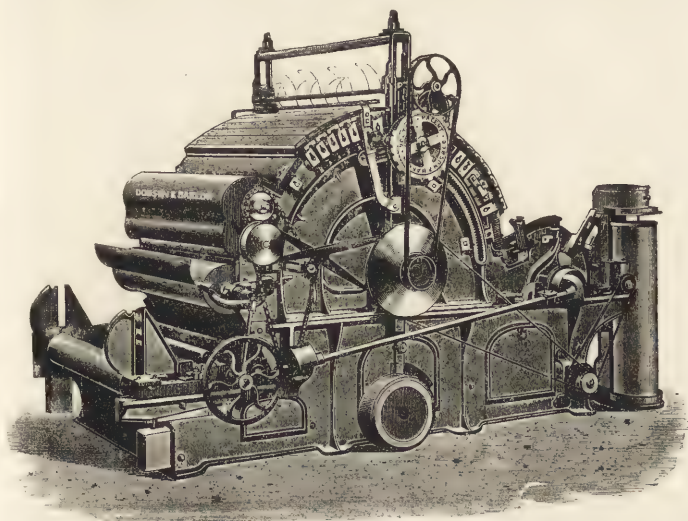
FIG. 68.—SELF-STRIPPING CARD. THE FLATS IN THIS MACHINE ARE STATIONARY.

and the finest wire at the last flat, so that the wire should change gradually finer every five or six flats, in order that the process may be equivalent to that of the action of the circular comb in the combing machines, where the tangled, matted cotton is first attacked by open coarse combs, and, as it is opened by these, gradually followed by finer combs.

The flats being fixed in position (fig. 68), it is possible to set

them very close, so as to practically comb with the last three or
four flats over the doffer.   Smoother carding can be obtained
when this is carefully attended to from the stationary card
than from any other description of machine.

   The Revolving Flat Carding Engine.—In this machine
the carding is accomplished by travelling or revolving flats,
which cover the upper portion of the cylinder (*see* fig. 69). They
are connected together by links, and reaching across the
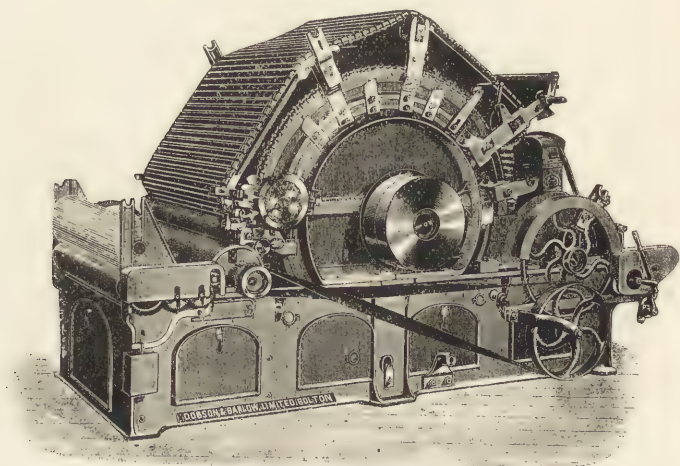
FIG. 69.—A REVOLVING FLAT CARDING ENGINE.

cylinder, rest at each end on a guide called the flexible bend.
These flats, which are about $1\frac{3}{8}''$ wide, are made of cast
iron, and are clothed with card teeth or wire of varying
degrees of closeness, according to the class of material to be
dealt with.   They travel forward very slowly, and as the cylinder
surface travels rapidly in the same direction, the fibres are
dragged through the teeth of the flats, and not only stripped of
the minute particles of dirt adhering to them, but are delivered

in such a free condition that a very slight pull is all that is required to place them in parallel order. The carding engine fitted with flats is the best for fine cottons, and delivers a smoother and silkier sliver than a roller card. Of course the clothing of the travelling flats must be all of one pitch, usually a little finer than that of the cylinder. The cotton is fed to the cylinder by means of a licker-in covered with saw-teeth, and after carding is transferred to a doffer clothed with wire. The doffer is stripped by a vibrating comb, and the web being 'gathered' to a pair of calender rollers, forms a sliver which is coiled down into a can.

The 'Simplex' carding engine shown is a good example of a machine suitable for all classes of cotton. The flats are very strong, and are so designed as to deflect as little as possible in working. When it is remembered that the distance between the wire teeth of the flats and the wire of the cylinder is regulated by thousandths of an inch, it will be seen that this is a most important point. One special feature of the particular machine mentioned is the simple but accurate manner in which the licker-in and its adjacent parts are set simultaneously; that is, the adjustments of the licker-in, the mote knives, and the undercasings are made at once. The knives and undercasings may also be independently adjusted if necessary (*see* fig. 71). The cylinder and doffer are clothed up to the extreme edges, the card sides are turned inside, so that the cylinder fits close up to the framing, dispensing with packings or wood linings; there are also flanges and other protections to prevent damage being done to the edges of the card wire. By these and other improvements perfect selvages are made, and an extra width of lap can be worked in the same floor space. Cards were formerly made 2″ wider on the wire than the width of the lap to be worked, 'but the Simplex' is made 1″ narrower on the wire than the

width of lap to be worked, thus, by this and other arrangements, economising very considerable floor space.

A further important improvement in this card is the patent cylinder and doffer cover with making-up piece combined. In
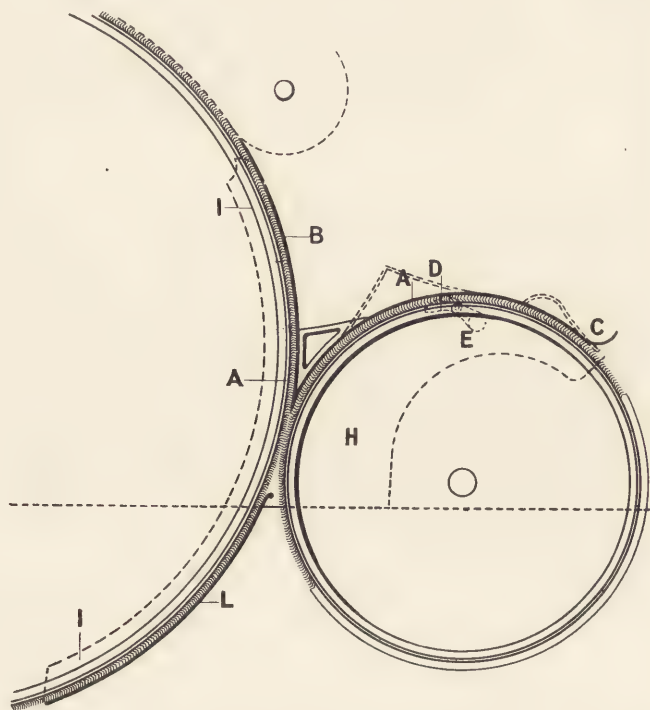
Fig. 69a.—Section showing the Doffer and part of Cylinder of the Card with Patent Cover.

fig. 69a this patent cover is very clearly shown. This cover is of steel, and is in three parts. One A, the portion that descends between the doffer and the cylinder, is planed and polished, so as to afford no chance of cotton catching and forming 'cat tails.' It is hollow in the inside, to form a box

to allow the strippings from the flats to fall into it. There is a
steel cover B hinged to this box in such a manner that there
is no joint perceptible next to the cylinder on the inside; and
it has also a cover C hinged to it in the front to cover it towards
the fly comb a sufficient distance to prevent dirt and dust
falling upon the doffer and being incorporated with the web.

What is generally known as the bend nose is done away
with, and in its place there is a separate piece on each side of
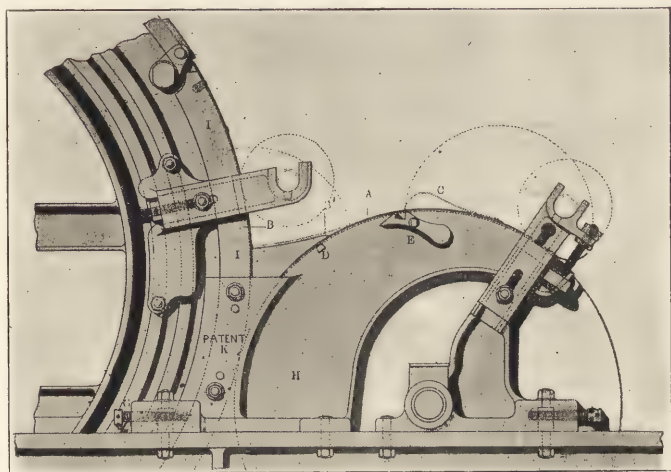
FIG. 70.—DIAGRAM SHOWING ARRANGEMENT FOR REMOVAL OF COVER WHEN
GRINDING THE CYLINDER AND THE DOFFER OF THE CARD.

the carding engine (fig. 70), which has a flange, a setting box,
and drag screw on the planed surface of the card side. One
portion H of this piece is concentric with the doffer, and is
turned or milled the correct radius. Another portion K
carries upon it a turned segment I which is fixed by two
screws and two pins. From this piece the segment proceeds
upwards as far as that portion of the bend where the flats
leave the cylinder, and in a downward direction to near the

bottom of the cylinder. The segment and the turned portion of the movable piece carrying it hold the box and covers that have just been described. The under portion of the turned segment carries a steel plate or plates L (fig. 69a), forming the front portion of the cylinder undercasing, so that it will be readily understood by moving the drag screw G, shown in fig. 70, that not only are the doffer casing and the front knife and cover set up practically concentrically with any change in the diameter over the points of the wire, but also the front part of the cylinder undercasing has been set up in exact proportion ; thus, once set, neither cylinder undercasing nor front knives nor doffer cover and box require any further attention so long as the card exists, and one setting on either side of the card will set the whole of the enumerated parts, thus imparting an element of certainty to what was previously at the best but a very uncertain operation.

The steel cover B, when turned down, assumes the form shown in the dotted lines B' in fig. 70, and when in this position permits the grinding to be performed, as also the stripping without any further displacement.

When it is desired, however, to test the gauge between the cylinder and doffer, the box is taken and moved circularly along the surface of the turned piece described, until the snug D is geared into the catch E, shown in fig. 70, the cover assuming the position shown in dotted lines on fig. 69, being safely held during the operation ; there is but one grinding and stripping fixing, and this fixing is arranged to be set radially towards the centre of the cylinder shaft, and the diameter of the grinding roller and the cylinder brush are kept so arranged that it is never necessary to alter the setting as between grinding and stripping.

The improvement that has most conduced to good single carding and large productions has been the employment of

the licker-in covered with inserted saw-tooth wire, and the employment of the dish feeder. Both these parts of the card are old, having been known for a good many years ; but, having been badly made and improperly understood, they did more harm than good. At one time there was an idea that it was impossible to card a good class of cotton with this dish feed and the licker-in saw-tooth wire, as it was thought the action was too rough and brutal for the fibres, and that loss of strength to the yarn would ensue. It is undoubtedly true that it would be possible to cut the cotton to pieces if an improperly arranged licker-in and dish feed were used ; on the other hand, it may be pointed out that, short of wilful action, no damage can be done to the cotton. The effect of the licker-in covered with this wire as compared with the old licker-in covered with sheets working at the feed by two feed rollers is this, that in the ordinary licker-in sheet wire it was impossible to strike down the heavy dirt with the same ease and certainty that it is now done. The tendency was for the licker-in to get choked, and this required constant stripping and grinding, and made more 'neps' than any other part of the card. The saw-tooth licker-in never wants grinding, and is always in a clean condition to do its work.

The teeth of the licker-in strike through a certain portion of the thickness of the lap of the cotton, so that it may be said that the heavy dirt is struck through the lower side of the lap, previous to the cotton being released for the licker-in to seize hold of and convey the fibres to the cylinder.

The knives employed under the licker-in (see fig. 71) are a particular and great improvement with regard to determining the amount of fly and dirt that should be taken out, and if these are properly set, any dirt adhering to the cotton fibre after being loosened from the feed part should be scraped off by the action of these sharp knives. This has eased the work of the carding engine itself to a very great extent, as the heavy work

is done entirely by the licker-in, and it may therefore be said that the improvements in the licker-in have contributed more than anything else to the large productions of the present day.
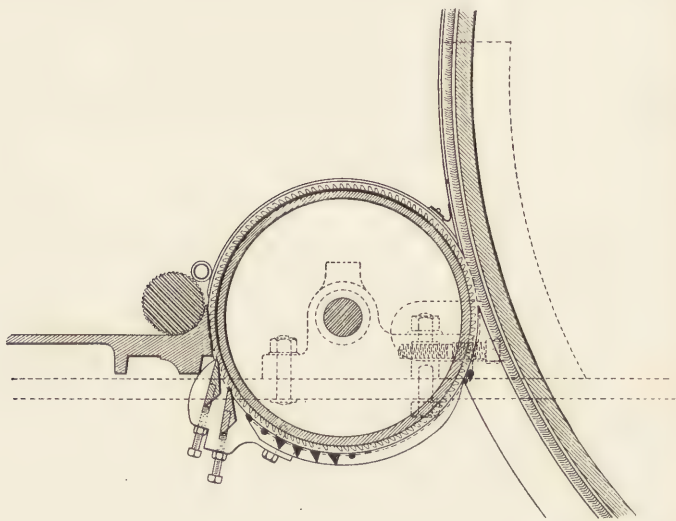
Fig. 71.—Section of Licker-in showing position and purpose of Mote Knives.

The Setting of Flats.—The proper setting of the flats is the most delicate but at the same time the most important requirement in a carding engine, because when the wire clothing has been worn or ground, it is requisite to preserve its exact concentricity with the cylinder. The accompanying view and diagram (figs. 72 and 73) illustrate the ingenious method adopted in Dobson and Barlow's 'Simplex' carding engine. The flats rest upon the flexible bend D, which is supported between five brackets F and the turned face of the fixed bend G, as shown in the small detached view.

The flexible has four pins fixed in it, and a fifth is found on the first bracket, each kept in contact with the curved

edge of the brackets. That end of the flexible over the doffer is held by a swivel or link H, which, being centred at K, would describe a complete circle when turned round. The
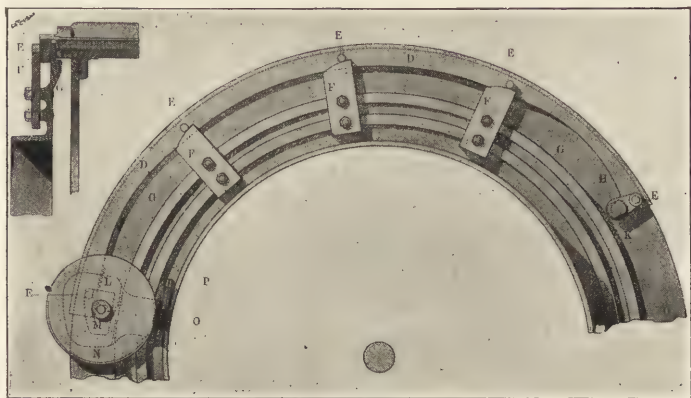
FIG. 2.—ARRANGEMENT FOR SETTING OF FLATS.
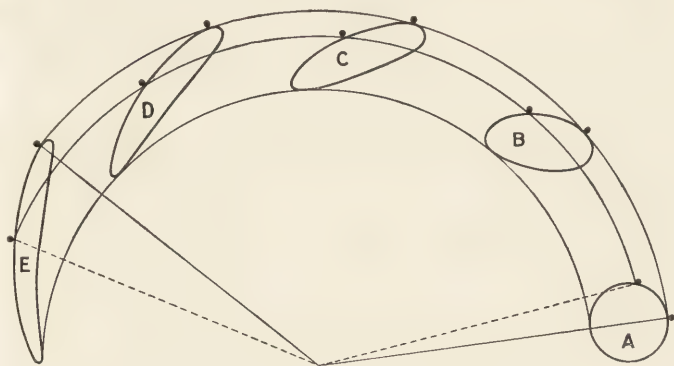
FIG. 73.—PATHS TAKEN BY THE FIVE PINS E SHOWN IN FIG. 72.

upper surfaces of the brackets F, which are really setting points, are turned to a curve which actually represents the travel of a point upon the flexible bend traced both radially and longitu-

dinally. The diagram (fig. 73) explains the principle upon which they are worked out. The three concentric lines show the extreme travel of the flexible, presuming that, instead of simply putting down the distance required for setting, the crank H is worked to the development of a full circle. It will be seen that the curves A, B, C, D, and E show the travel of the five setting points, starting from H. The curves are formed by a milling machine with an enlarged copying apparatus. The real setting point is at the end over the licker-in, where a fine pitch rack is cut into the inside edge of the flexible, and gears with a small steel pinion. The latter is fixed on the axis of a fine indexed worm wheel N of 160 teeth. This is turned by a worm O, which has on its shaft a square P for a key. The index wheel N is engraved with graduations showing the amount of setting that has taken place. The dial being marked in fiftieths of an inch, it follows that when the pins E are drawn down the surfaces of the brackets F, the pointer will register about the two-thousandth part of an inch in downward movement of the flexible bend and flats. This arrangement is found on both sides of the card, and, to prevent unauthorised persons interfering with it, is secured by a lock and key.

It is also important to preserve the concentricity of the flats with the centre of the cylinder shaft itself. The cylinder of a carding engine is of a great weight, and, as the direction or motion is always the same, there is a tendency, more or less, to wear the bearings, and consequently to remove the centre of the cylinder forward. The pull of the driving strap will cause this also. Fig. 74 shows an adjustable cylinder pedestal, which provides absolute accuracy in this respect. The phosphor bronze bush A is placed within an eccentric B, which in turn is enclosed in another eccentric C. These and the bush are contained in the circular hole of the bend pedestal. Both of these eccentrics have an ear, carrying

a fixed stud E, connected by screw links to the eye-bolts G swivelling in the lower part of the pedestal. They are fitted
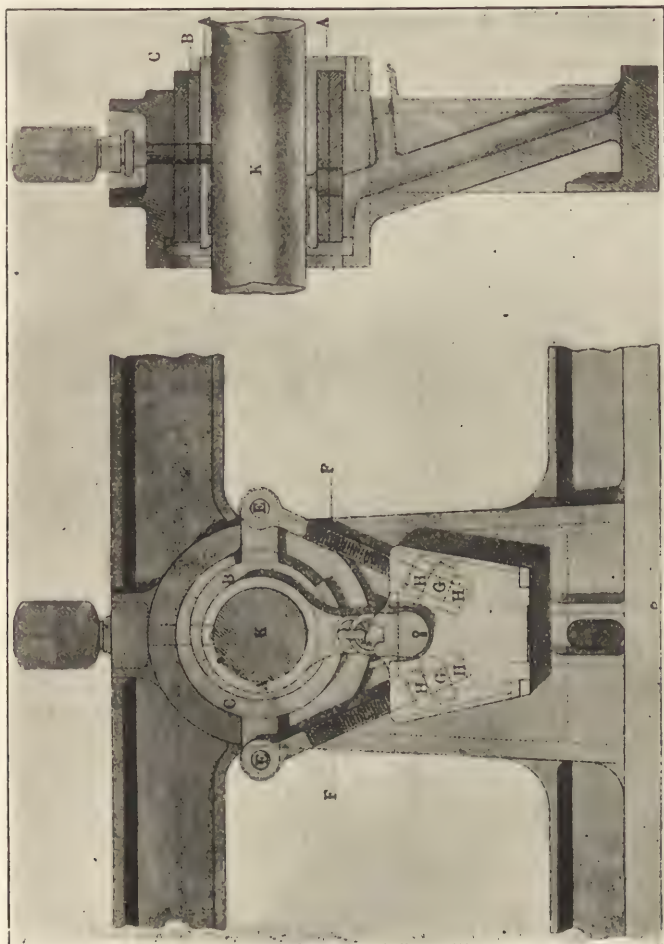
Fig. 74.—Diagrams Giving Details of Dobson and Barlow's Card Cylinder Pedestal.

with lock-nuts. The eccentrics having each the same throw, when they are moved round by turning the nuts the centre of

the interior bush will move round the centre of the eccentric
that has been disturbed. If both eccentrics are turned through
the same distance, the inside bush and the cylinder centre are
moved in a straight line vertically. When the movement of
one eccentric is made to exceed that of the other, the cylinder
centre is displaced laterally, and the arrangement is thus as
useful to compensate for side wear as for downward wear.
This pedestal has another advantage, as it prevents any length-
way displacement. The inside bush is flanged, and has a slot,
through which passes a stud screwed into the pedestal.

The various parts are made to gauges, and no play is
allowed. When once set the lock nuts can be tightened, and
the adjustment is fixed. Of course all this setting would be
useless if the centre of the cylinder was not originally regulated.
This is done at the works by means of a tester gauge, which
perfectly fits both the cylinder shaft κ and the bush c. If the
gauge has any play at all, the nuts н will require turning, and
the tester shows at once where this must be done. The adjust-
ing arrangement is covered by a box, and fastened by a lock
and key similar to that of the flexible bend appliance.

Change-places in Carding Engine.—There are two
change-places in a carding engine : (1) the barrow wheel, which
gives the speed to the doffer and feed roller, and (2) the feed
wheel, which alters the thickness of the sliver delivered, or the
weight per yard. A larger barrow wheel increases the produc-
tion by turning out more length without altering the weight of
sliver per yard, but the quality is not quite so good. On the
other hand, a smaller barrow wheel causes less length to be
delivered, but it is better carded. A larger feed wheel makes
a thicker or heavier sliver, because of the less draft. A smaller
feed wheel will reduce the weight of the sliver by causing a
greater draft. This is evident, seeing that a less amount of lap
would be taken in.

Whenever the weight of carding per week is increased, the number of strippings and the amount of grinding ought also to be increased correspondingly, because they are the two vital considerations in carding, and too great importance cannot be attached to them, especially the grinding ; for unless a really smooth point on the wire is ground, it is impossible to strip clear.

Production of Cards.—Hours run, 53 out of $56\frac{1}{2}$. Doffer, $24\frac{3}{4}$ inches diameter with wire.

Revolutions of Doffer per Minute	Weight of Sliver per Yard	Hank Carding	Lbs. per Card in $56\frac{1}{2}$ Hours
	grains		
18	60	·138	1,058
16	,,	,,	941
15	,,	,,	882
$15\frac{1}{2}$	54	·154	825
$14\frac{1}{2}$	,,	,,	765
$13\frac{1}{4}$	,,	,,	706
$12\frac{3}{4}$	,,	,,	676
$13\frac{1}{2}$	48	·173	634
$12\frac{1}{4}$	,,	,,	581
$11\frac{1}{4}$	,,	,,	528
10	,,	,,	470
10	44	·189	431
10	40	·208	392
10	36	·231	350
$9\frac{1}{4}$	33	·252	300
9	30	·277	263
8	,,	,,	235
7	,,	,,	205

Grinding.—The flats on a ' revolver ' card are ground by a flat-grinding motion, usually applied to a carding engine as a part of the machine itself. The chief point to be considered in flat grinding is the preservation of the correctly-shaped working surface of the flat. The wire surface is not parallel to the travelling surface of the flat, on account of the 'heel,' or bevel, which is made on each flat at the side where the cotton enters. The grinding must therefore be made parallel to the wire surface, and it necessitates a special surface being arranged for the

K

flats to travel on during grinding. In the motion illustrated in
fig. 75, which is a Patent Anti-flexion Grinding Motion, the
flats pass across two rollers, as shown in the top centre
sketch. They are geared together, and a bed with a narrow

A. B. C. D. SLIDING SURFACE WHEN GRINDING.
A. B. C. E. SLIDING SURFACE WHEN CARDING.
B. F.   CLEARANCE FOR RAISED SURFACE ON SLIDE WHEN GRINDING.
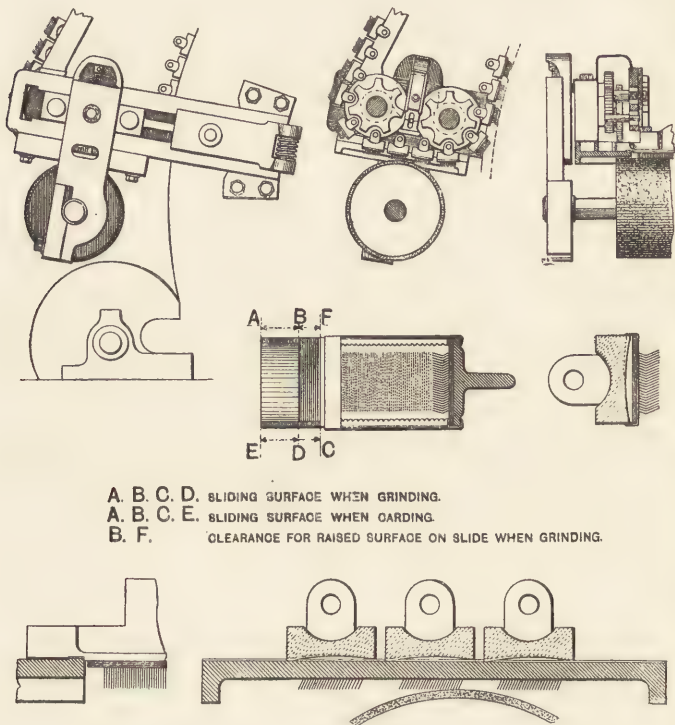
FIG. 75.—SEVEN DRAWINGS GIVING PARTICULARS OF THE PATENT ANTI-FLEXION
GRINDING MOTION.

raised strip (*see* bottom figure) occupies the space between
them. At the end of each flat a small part of one sliding
surface is cut away to correspond with the bed, so that
as soon as each flat is brought upon the bed it is tipped up
slightly, and the correct inclination is obtained. As the flats
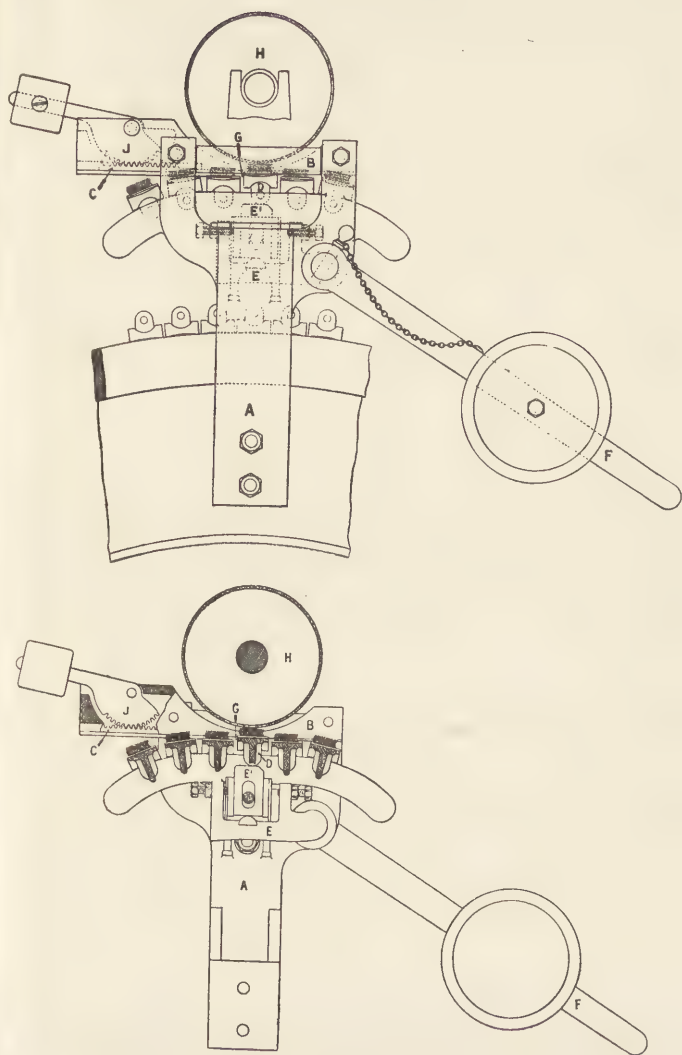
FIGS. 76, 77.—IMPROVED METHOD OF FLAT GRINDING.

pass over this prepared surface they are brought into contact with the emery roller and ground. The motion is very simple; its parts are shown in the figure, and also its position over the licker-in.

Another recently introduced method of flat grinding is the improved adaptation of McConnel and Higginson's Patent. It is
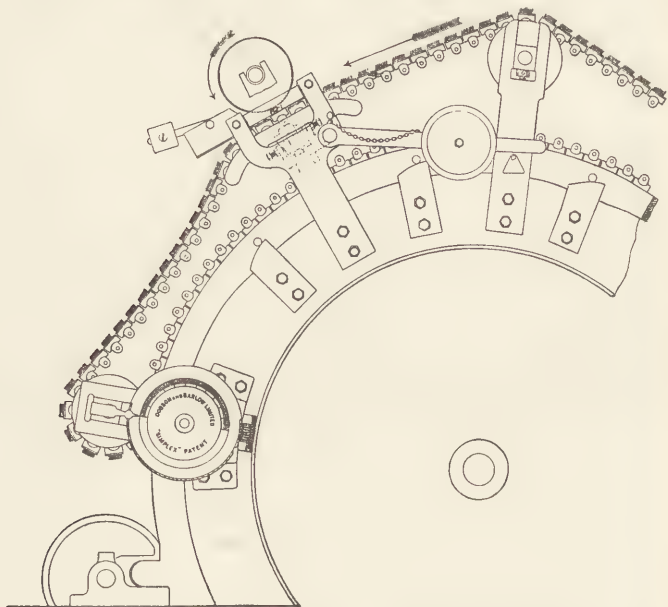
Fig. 78.—Grinding Apparatus in Position on the Card.

illustrated in figs. 76, 77, and 78, the last of which shows the apparatus in position on the card. To the grinding bracket A (figs. 76 and 77) a grooved guide B is fixed, in which a toothed bar C can slide. To the bottom of this bar is attached a wedge curved to the radius of the flexible band. The flats D are pressed with their working facings against this wedge by means of the lever E and slide E¹, the other end F being loaded by a weight or

spring. As the flats revolve each of them seizes the projection G of the wedge, and carries it along until the wires have passed under the grinding roller H. The flat in its forward travel comes into contact with an incline attached to the back of the guide B, which presses the flat down and so releases the wedge, and by means of the weighted toothed segment J it is returned to its original position in readiness for the next flat. The accumulation of fluff or dirt on the working surface is entirely avoided by these surfaces being on the under side of the guide B.

By changing or altering the wedge, the bevel of the wire can easily be altered if required. It is advantageous to support the flats on the working surfaces rather than on special faces at the back, inasmuch as, in the latter system, any inequality in the inclination of these fixings to the working surface, or in the distances between these surfaces, will result in different lengths and bevel of wires.

Calculations on the Card.—To find the different speeds of the various parts of the cards. (*See* fig. 79.)

(1) *Speed of cylinder*.

> Line shaft = 220 revolutions per minute.
> Drum = 11″. Pulley on cylinder = 16″.

Therefore the latter being a larger pulley goes $\frac{11}{16}$ times the speed of the former.

Speed of cylinder pulley $= \dfrac{220 \times 11}{16} = 151$ revolutions of cylinder.

(2) *Speed of licker-in*.

> Speed of cylinder = 151 revolutions.
> Pulley on cylinder = 15″. Pulley on licker-in = $6\frac{1}{2}$″

Therefore the latter being a smaller pulley goes $\frac{15}{6\frac{1}{2}}$ times the speed of the former.

Speed of licker-in $= \frac{151 \times 15''}{6\frac{1}{2}} = 348\cdot4$ revolutions of licker-in.
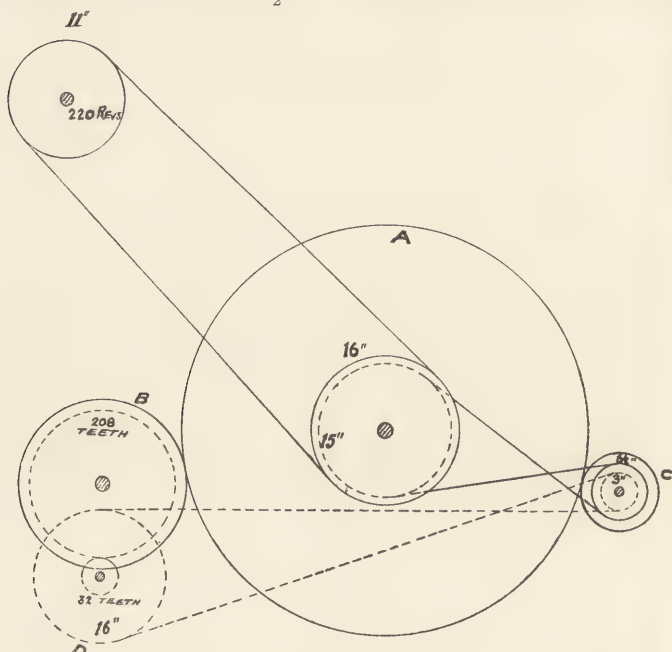
FIG. 79.—DIAGRAMMATIC SECTION OF THE CARD FOR THE PURPOSE OF CALCULATIONS.

A. Cylinder ; B. Doffer ; C. Licker-in ; D. Barrow pulley.

(3) *Speed of barrow pulley.*

Licker-in 348·4.

Pulley on licker-in $= 3''$.   Barrow pulley $= 16''$.

Therefore the latter being a larger pulley goes $\frac{3}{16}$ times the speed of the former.

Speed of barrow pulley $= \dfrac{348 \cdot 4 \times 3}{16} = 65 \cdot 3$ revolutions of barrow pulley.

(4) *Speed of doffer.*

Barrow pulley $= 65 \cdot 3$ revolutions.

Wheel on barrow pulley $= 32$ teeth.   Wheel on doffer $= 208$ teeth.

Therefore the latter having a greater number of teeth will go $\dfrac{32}{208}$ times the speed of the former.

Speed of doffer $= \dfrac{65 \cdot 3 \times 32}{208} = 10$ revolutions of doffer.

(5) *How to find the productions of the carding machine.*— Suppose it is required to find the production of a card when the following are given :—

Weight of sliver $= 40$ grains per yard.

Diameter of doffer $= 24 \cdot 75$ inches (including $\cdot 75''$ wire).

Actual working $= 53$ hours.

Revolutions of doffer $= 9$ per minute.

$24\frac{3}{4}''$ diameter $= 77 \cdot 75$ circumference.

$$\frac{77 \cdot 75 \times 60 \times 53 \text{ hours} \times 9 \times 40 \text{ grains}}{36'' \times 7000 \text{ grains}}.$$

This equals lbs. per week delivered.

(6) *On drafting a carding machine.*—Suppose a scutcher lap is taken which weighs twelve ounces to the yard and we require a sliver forty eight grains to the yard.   This is very commonly called a two-pennyweight sliver.   The following is the method to be pursued, after duly allowing for waste, which is usually put down at 5 per cent.

1 oz. $= 437 \cdot 5$ grains.   12 ozs. $= 5250$ grains.

5% of this $= \dfrac{1}{20} \times \dfrac{5250}{1} = \dfrac{525}{2} = 262\frac{1}{2}$ grains loss.

This leaves $4987\frac{1}{2}$ grains.   There are to be 48 grains to the

yard in sliver, so that $4987\frac{1}{2} \div 48$ or $\dfrac{4987\frac{1}{2}}{48}$ will give what is called the *draft*, or in this case it is the ratio between the length of lap and the length of the sliver.

$$\frac{4987\frac{1}{2}}{48} = \frac{\overset{9975}{\frac{2}{48}}}{\underset{1}{\vphantom{x}}} = \frac{9975}{96} = 96)\,9975\,(103\cdot9.$$

$$\begin{array}{r} 96 \\ \hline 375 \\ 288 \\ \hline 870 \\ 864 \\ \hline 6 \end{array}$$

103·9, say 104 draft.

(7) *To find draft.*—(1) Between lap rollers and feed rollers. (2) Between doffer and calender rollers. *See* fig. 79*a* for figures used in the following calculations.

Note.—In each case refer to the general rule given with the scutchers.

1. Diameter of lap rollers . . . . 6″
   ,, ,, feed ,, . . . $2\frac{1}{4}''$
  Wheel on lap roller . . . 59 teeth
   ,, ,, feed ,, . . . 21 ,,

$$\frac{59}{21} \times \frac{2\frac{1}{4}}{6} = \frac{59}{21} \times \frac{\overset{9}{4}}{\underset{1}{6}} = \frac{59 \times 9}{21 \times 4 \times 6} = 1\cdot05 \text{ draft.}$$

2. Diameter of doffer . . . . . $24\frac{3}{4}''$
   ,,   calender roller . . 4″
  Wheel on end of doffer . . 208 teeth
   ,, ,, calender roller . 28 ,,

$$\frac{208}{28} \times \frac{4}{24\cdot75} = \frac{208 \times 4}{28 \times 24\cdot75} = 1\cdot2 \text{ draft.}$$

3. The draft between the feed roller and doffer can also be found by same rule, and then the total draft can be obtained by multiplying all the three drafts together.

Diameter of feed roller		.	.	$2\frac{1}{4}''$
,, doffer	.		.	$24\frac{3}{4}''$
Wheel on end of doffer	.	.	.	26 teeth
Driving side shaft bevel	.	.	.	32 ,,
Change bevel on shaft	.	.	.	21 ,,
Driving feed roller wheel	.	.	.	154 ,,

$$\frac{26 \times 4 \times 32 \times 154}{9 \times 24\frac{3}{4} \times 21} = 109\cdot5 \text{ draft.}$$

4. Total draft $= 109\cdot5 \times 1\cdot2 \times 1\cdot05 = 137\cdot97$, say 138.

Note.—The particulars for the four preceding calculations are taken from the card in the Bolton Technical School.

(8) *On the draft between the feed roller and the doffer.*—The purpose of this is to change the weight of the sliver without altering the weight of the lap. As a matter of fact, changing the wheel marked A in fig. 79*a* alters the speed of the feed roller either one way or the other, which will, of course, give a different weight of sliver.

This is brought about as follows:—Suppose the wheel A is to be changed, and one with a greater number of teeth in it is substituted. A direct result of this change will be to speed up the feed roller, and consequently a greater amount of cotton is sent through the machine.

If no alteration is made in the barrow wheel shown at B (fig. 79*a*) only one result will follow, viz. *a thicker sliver.* This is clear from the following reason : a greater amount of cotton is taken in by the feed roller and carried forward by the licker-in to the cylinder. Here it is carded and passed on to the doffer, and delivered as a sliver of heavier weight. Now let it be supposed that from the same lap a draft of 110 is required. If the machine previously gave a draft of 104, and one of 110 is required, the speed of the feed roller must certainly be decreased, because a lighter sliver is required. Consequently the change

wheel at A is altered, and one having fewer teeth in it is put in its place

(9) *To alter from one weight of sliver to another.*

PLAN OF CARD.

LAP ROLLER 6" DIA.

FEED ROLLER 2½" DIA.

LICKERIN 9¾" DIA. (ON WIRE)

16" ROPE PULLEY

CYLINDER 50¾" DIA (ON WIRE)

DOFFER 24¾" DIA (ON WIRE)

DOFFER COMB

25" ROPE PULLEY

14" ROPE PULLEY

CALENDER BLOCK 4" DIA.

END ELEVATION OF DOFFER AND BARROW WHEELS

DOFFER WHEEL
208
32 TEETH
BARROW WHEEL

BARROW WHEEL

A CHANGE PLACE FOR DRAFT.

B " " SPEED OF DOFFER.
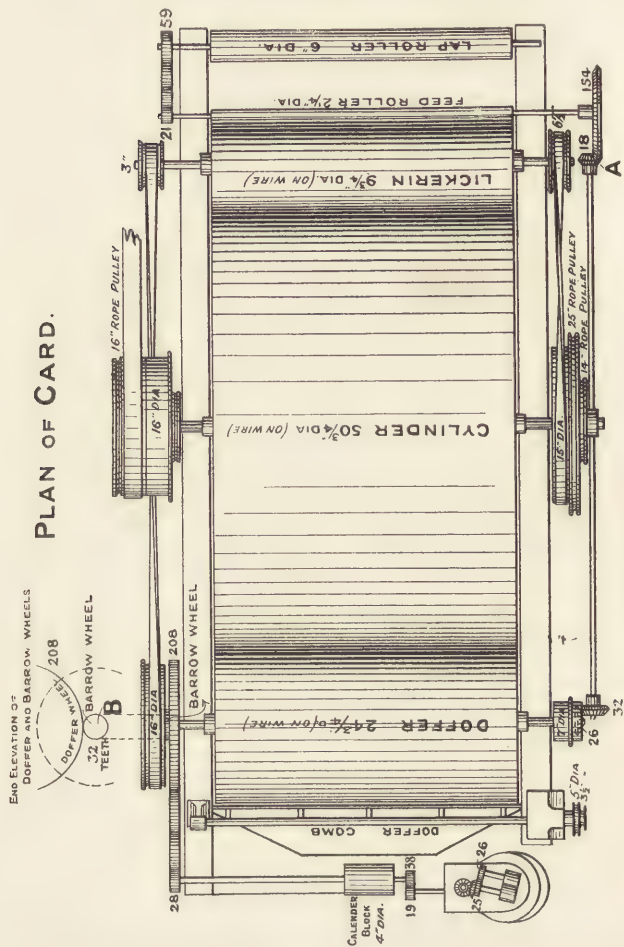
FIG. 79*a*.—PLAN OF THE CARDING ENGINE SHOWING ELEVATION ALSO OF BARROW WHEEL AND DOFFER.

Rule.—Change the side shaft bevel in proportion to weight of sliver required.

Example.—You are making a sliver of 30 grains to the yard, and desire to make one of only 27 grains per yard.

Find the change pinion for the lighter weight, the one on being a 25. From what has just been stated a wheel with fewer teeth will be wanted.

$$\frac{27}{30} \text{ of } 25 \text{ or } \frac{27 \times 25}{30} = 22{\cdot}5.$$

Constant Dividends for obtaining the hank when given lengths are wrapped.

It frequently happens that calculations such as the following meet the students attending classes or in actual experience :—

1. If 2 yards of carding weigh 104 grains, what part of a hank is it?

$$\frac{8\frac{1}{3} \times 2}{104} = {\cdot}1602.$$

2. If 30 yards of roving weigh $62\frac{1}{2}$ grains, what hank is it?

$$\frac{8\frac{1}{3} \times 30}{62\frac{1}{2}} = \frac{250}{62{\cdot}5} = 4 \text{ hank roving.}$$

3. What ought 60 yards of a $4\frac{1}{2}$ hank roving to weigh?

$$\frac{8\frac{1}{3} \times 60}{4\frac{1}{2}} = \frac{500}{4{\cdot}5} = 111 \text{ grains.}$$

If 7000 grains equal one lb. and this be divided by the number of grains one hank weighs, the quotient will be the number of hanks in one lb.

But it is not required to wrap a full hank (840 yards) except in very fine numbers. When, however, we take a less length than a hank, or 840 yards, the dividend (which in the case just given was 7000) will be less. In other words, it will be exactly in the proportion to 7000 as the length taken is to 840 yards. This is more fully treated under the heading of 'Testing Machines.'

For example, if we take 120 yards, then 840 : 120 as 7000 is to required dividend ;

$$= \frac{7000}{1} \times \frac{\cdot 120}{840} = \frac{7000}{1} \times \frac{1}{7} = \frac{1000}{1} = 1000$$

If then the dividend for 843 yards be 7000, then for one yard it will be $\frac{7000}{840} = 8 \cdot \dot{3} \dot{3}$, or $8\frac{1}{3}$.

<div align="center">TABLE OF YARDS AND CONSTANT DIVIDENDS</div>

Yards.	Dividends.	Yards.	Dividends.
1	8·33	10	83·33
2	16·66	15	125·00
3	25·00	20	166·00
4	33·33	30	250·00
5	41·66	40	333·33
6	50·00	60	500·00
7	58·33	120	1000·00
8	66·66	One hank (840)	7000·00
9	75·00		

(10) *Alteration of barrow-change wheel.*—This is the wheel which has to be changed when we desire to vary the weight produced by carding the material more or less, without altering the hank sliver.

Rule.—Multiply wheel on by the weight required, and divide by present weight.

Example.—Suppose we are producing 600 lbs. per week with a 22 barrow-change wheel. Find wheel to produce 750 lbs. per week.

$$\frac{750 \times 22}{600} = 27 \cdot 5 \text{ barrow wheel required.}$$

(11) *To find speed of flats per minute.*

The best practical method of doing this is to mark their position on the bend with chalk, and to actually time with a watch the distance moved per minute.

Sometimes, however, we may have particulars supplied to us by which we may find the speed of the flats without being actually at the card. The following is an example :—

Revolutions of cylinder 155 per minute. On cylinder shaft is a 7″ pulley driving a 9″ stud pulley. On the same stud is a single worm driving a 26-worm wheel. On the same stud as this worm wheel is a second single worm driving a second worm wheel of 40 teeth. The flat wheel is 8″ diameter, and is on same shaft as flat chain wheel. Find speed of flats.

$$\frac{155 \times 7 \times 1 \times 1 \times 8 \times 22}{9 \times 26 \times 40 \times 7} = 2\cdot 91 \text{ inch per minute.}$$

(12) *To find the length of fillet required to cover a cylinder.*

It is useful to remember that the circumference of a circle equals the diameter multiplied by $\frac{22}{7}$.

Suppose the cylinder of the card is $50\frac{3}{4}$″ in diameter (*see* fig. 79*a*) and 38″ wide, and the width of the fillet is $1\frac{1}{2}$″.

It is clear that the length of fillet to go once round the cylinders will be $50\frac{3}{4} \times \frac{22}{7}$ or $\frac{203}{4} \times \frac{22}{7}$ inches.

Then to cover 38″ with filleting $1\frac{1}{2}$″ wide, we shall require as many strips as there are $1\frac{1}{2}$″ in 38″, or

$$\frac{38}{1} \div 1\frac{1}{2} = \frac{38}{1} \times \frac{2}{3} = \frac{76}{3} \text{ strips} = 25\frac{1}{3}.$$

To go once round required $\frac{203}{4} \times \frac{22}{7}$ inches.

Therefore to go $25\frac{1}{3}$ times round will require $\dfrac{203}{4} \times \dfrac{22}{7} \times 25\frac{1}{3}$

$$= \frac{203}{2} \times \frac{11}{7} \times 25\frac{1}{3} = \frac{\overset{29}{\cancel{203}}}{\cancel{2}} \times \frac{11}{\cancel{7}} \times \frac{\overset{38}{\cancel{76}}}{3} = 336\cdot4 \text{ feet.}$$

(13) *Weight on feed roller.*—The feed roller of a carding engine has pressure put upon it by a weighted lever. The fulcrum is at one end of the lever, and it is 12″ from the fulcrum to the centre of a 10-lb. weight at the other end of the lever, and it is 3″ from its fulcrum to the centre of the weight hook, which receives and puts the pressure upon the feed roller. What is the pressure put upon the feed roller by this arrangement? (Union of Institutes Exam. 1896.)

$$\frac{12 \times 10}{3} = 40 \text{ lbs.}$$

Both ends of the feed roller are weighted alike, and therefore the total weight on feed roller would be

$$40 \times 2 = 80 \text{ lbs.}$$

(14) *To find total draft of card between lap roller and calender rollers at one operation.* (*See* general rule given with scutcher calculations. *See* also fig. 79a.)

On a revolving flat carding engine the doffer is $24\frac{3}{4}''$ diameter, and the calender rollers or blocks are 4″ diameter. On one end of doffer is a 26 bevel wheel, driving a 32 side shaft bevel. On the other end of the side shaft is an 18 change bevel, driving a 154 on feed roller. A 21 on feed roller drives a 59 on lap roller, the latter being 6″ diameter. A 208 on doffer drives, by means of two carriers, a 28 on bottom calender shaft.

$$\frac{208 \times 4 \times 32 \times 154 \times 59}{28 \times 26 \times 18 \times 21 \times 6} = 146\cdot5 \text{ total draft.}$$

CHAPTER XIII

Combing.—The Combing Process is used for the pro-
duction of yarns of good quality, or those required to be
exceptionally strong and even. The use of the Comber and
its preparatory machines greatly adds to the cost of production,
but the yarns are the most valuable, especially to sewing
cotton manufacturers, because a greater proportion of the
strength possessed by individual fibres is utilised.

The combing of cotton involves the removal of all fibres
that do not approximate to a required length, and as Egyptian
cotton, from which the high qualities of yarn are made, contains
a very large percentage of short fibres, the introduction of
these special machines is very advantageous. The strongest and
evenest yarns are those in which the fibres are as nearly as
possible the same length, and the comber is therefore indis-
pensable in many branches of the trade.

Sliver Lap Machine (fig. 80).—The first of the series in
this process is the Sliver Lap Machine, the object of which is
to unite in a sheet or lap a number of slivers from the card
and form them into a lap for the comber, or for the Combined
Draw and Lap Machine when the latter is included. From
16 to 20 (but usually 16) ends or slivers from the cards are
placed behind the sliver lap machine, and drawn through
guides (shown in fig. 80) to a 'draw box' of three lines of
rollers. After being drawn the cotton passes between a pair
of calender rollers in the form of a sheet, and is wound on to a
bobbin which turns between two revolving iron plates. These

plates keep the edges of the lap uniform by keeping them free
from friction.

The resultant lap, if intended for the comber, is made of
the width required by that machine, which varies from 8″ to
10″ ; but if they are made for the combined machine they are
rather narrower, to allow for spreading in the drawing.

The lap machine is fitted with a stop motion which
instantly stops it when a sliver breaks.   The balanced spoon
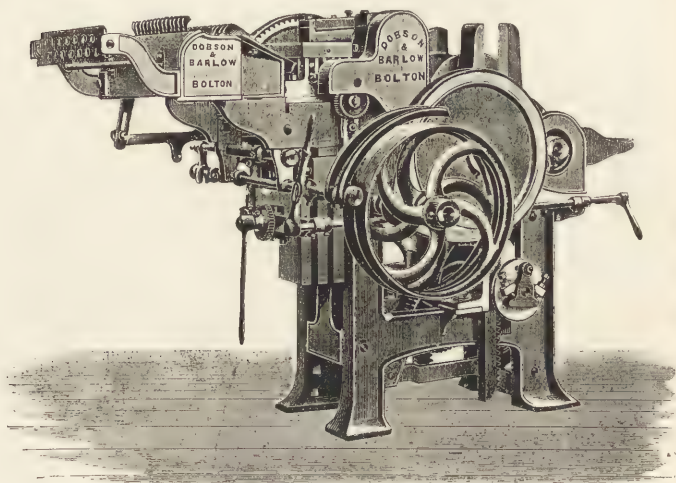
Fig. 80.—Sliver Lap Machine.

levers can be seen in the illustration.   The combined draw
and lap machine, or ribbon lapper, as it is sometimes called,
is not absolutely essential, but is certainly a great improvement
in the preparation of comber laps.   It was always usual to put
the slivers through one process of drawing and then to use the
sliver lap machine just described for making into a lap ; but
the more modern system is to use the sliver lap machine first,
and then further prepare the lap for the comber in the draw

frame and lap machine combined. This is illustrated in fig. 81. There is a creel behind to hold six laps from the sliver lap machine, and these being drawn through four pairs of rollers, each lap emerges in the form of a ribbon. By means of curved plates these ribbons are placed evenly one upon the other, and compressed by calender rollers, and made into a lap.

The one great benefit arising from the use of these machines is the almost perfect parallelisation of the fibres.
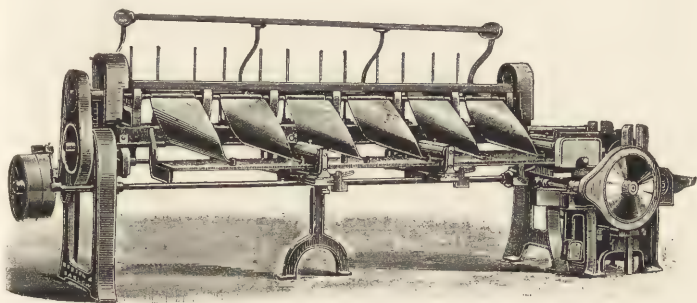
Fig. 81.—Combined Lap and Draw Machine, or 'Ribbon Lapper.'

It is evident that if the fibres are laid straight instead of crossed or curled they cannot be torn or injured by the combs, nor can they themselves injure the combs. This advantage of avoiding broken fibres is found to make a very appreciable difference in the waste made by the comber, but, what is more important, the yarn produced is much stronger and evener.

The production of the combined draw and lap machine varies, according to the class of cotton worked, from 450 to 500 lbs. per day of 10 hours, or from 2,500 to 2,800 lbs. per week.

The sliver lap machine will produce about the same weight.

The Combing Machine.—A comber has usually six or eight 'heads'—that is to say, the machine is intended to deal with six or eight laps at a time. Fig. 82 shows the general appearance of a six-headed comber on 'Heilmann's' principle. There are other forms of the comber, but the one chosen for description here is probably the best in use. The following description of the mechanism and action of one head will suffice, as every head is, of course, the same.

The action of the comber will be more easily followed if it is remembered that the machine is required to detach a piece of the lap, to comb it, and to attach it to the already combed part of the material. Fig. 83 is a section through the working parts of the ordinary combing machine with one set of combs. The lap is placed upon the two fluted wooden rollers, and, being unrolled, the material is conveyed down a lap plate rather wider than the lap to the feed rollers F F, which have an intermittent motion imparted to them by means of a cam. The bottom roller drives the top by frictional contact. The length delivered by these feed rollers at each movement depends on the 'setting' and 'timing' of the machine, which varies according to the length of the staple being combed. This portion of the cotton reaches the cushion G and the nipper H, and when sufficient length has been delivered H descends and, pressing against the cushion G, holds the tuft of cotton firmly. The nip is safely effected by letting a piece of thick leather or other substance into the jaw of the nipper H. While the cotton is held here for an instant the combs or needles B of a revolving cylinder come in contact with it, and, passing through, comb away all the short fibres. There are seventeen rows of needles in this segment, or 'half lap,' and the pitch of them becomes gradually finer, so that the whole of the fibres are thoroughly treated. The waste then combed out is carried round to the path of a revolving brush, the bristles of which pass
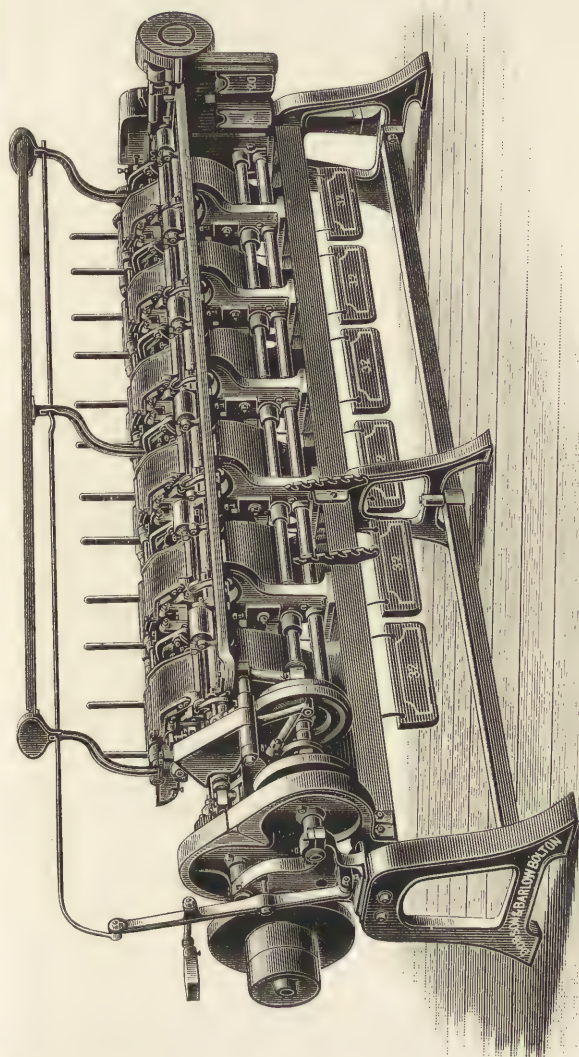
FIG. 82.—COMBER MACHINE OF SIX HEADS ON 'HEILMANN'S' PRINCIPLE.

through the combs and clear them. Then the brush is itself immediately stripped by the doffer behind. The direction of

Fig. 83. Section through ordinary Combing Machine.

A. Cylinder centre; B. Brush; C. Fluted segment; D. Detaching rollers; E. Leather covered roller; F. Feed rollers; G. Cushion plate; H. Nipper Lever; K. Centre of Nipper Lever; L. Nipper and R. Nipper Cam levers; S. W. and Y. Stop screws.

the doffer and brush are shown by arrows. Now the length of lap delivered by the feed rollers has not all been combed, and so at this point the detaching of the tuft takes place, and the other part is combed by the top comb in the following manner :—

Beyond the nippers are three rollers, the leather-covered roller E and the fluted detaching rollers D D, all of which move intermittently. The leather roller E is driven by friction with the bottom fluted roller, moving round it at certain moments.

Directly the needles on the cylinder have passed through the cotton held by the nippers the fluted segment C of the cylinder comes forward, and at the same moment the nipper H is further depressed, pushing the lower jaw G down so as to lay the combed portion upon the segment. Meanwhile the leather roller E is being moved round D, and, coming in contact with the flutes of the segment, rotates, detaching the portion of lap and carrying it forward. Simultaneously the nipper H opens, the top comb comes down, and the tail end of the cotton is drawn through it and combed, thus being freed from all short fibres that may have been held by the nipper.

The detaching and combing has now been performed, and the tuft of combed cotton only remains to be attached to the end of the sliver already operated upon. This is effected in a very ingenious manner by the use of a cam. The detaching roller D is turned back part of a revolution, carrying with it a small portion of the already combed sliver, and on this the newly combed tuft is laid, and D immediately coming forward in the opposite direction a greater distance, it follows that the newly combed fibres are always laid on to a thin length of sliver. In other words, suppose D moves back one-third of a revolution, carrying a thin portion of sliver back, and then moves forward two-thirds of a revolution, it is evident that the overlap is made equal to one-third, and when the roller again

moves back towards the cylinder it is only this 'single' thickness that returns. The short fibres and impurities which are taken from that end of the tuft which is last combed are held until the next passage of the needles, when they are stripped in the same manner as the others.

The leather roller E is put in and out of contact with the fluted segment C by the lever S centred at T ; this lever is worked through another lever, R, from the lifter cam.

The web of cotton when delivered into the sliver tin is gathered by a guide and passed through a pair of calender rollers, the uppermost of which is heavy enough to compress it to the coiler, by which it is coiled down into a can similar to the sliver from a carding engine. These various operations are performed very rapidly, the usual speed of the cylinder being 80 revolutions per minute ; thus the number of nips are 80 per minute.

The 'Duplex' Combing Machine, a section of which is given in fig. 84, is the most improved form of comber. The cylinder has two sets of combs and two fluted segments, which, with the necessary alterations in the arrangements for working the feed, nip, and detaching motions, enable the machine to give 120 nips per minute with the cylinder running only at 60 revolutions. The operations above described are all performed during half a revolution and repeated during the other half.

The production is increased in proportion to the number of nips per minute, that is to say, by 50 per cent., and the same quality of work is also maintained. All the motions of the feed, nippers, and detaching rollers are obtained from cams. The nipper lever H, which is centred at I, is actuated through the rod K and lever L from the nipper cam. The cradle lever which carries the centre I is itself centred at W. The movement of the cushion is controlled by the shape of the cam and by the setting screws Y,

Referring to fig. 84, it will be seen that the piecing motion
is derived from the quadrant cam.   The quadrant carries a
bowl, x, which engages with the cam.   The toothed part of the
quadrant gears with a pinion, P, on the end of the fluted detach-
ing roller D, these connections being all marked in dotted lines.
The shape of the cam is such that the detaching roller D is
caused to turn backwards a given distance and then turn for-

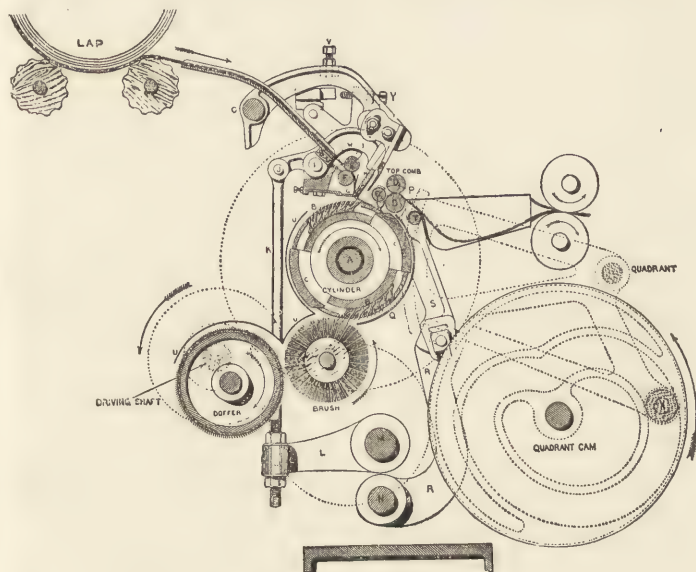Fig. 84.—Section of 'Duplex' Combing Machine.

ward a greater distance.   When this is done the rollers D
and E are stationary and the combing is taking place, to
allow for which the quadrant cam has a portion of its revolution
idle.

The movement of the pinion P is transmitted to the fluted
roller D through a clutch wheel or friction cone, which is thrown
out of gear when the combing process is going on and put in

gear as it finishes, thus allowing the cam to act on the quadrant
and repeat the backward and forward motion. The top comb
is centred at o, and its setting is effected by a set screw, v. The
waste brush is arranged and driven in such a manner that when
the bristles wear down and become less effectual it can be
speeded as desired and set nearer to the path of the comb
cylinder.

The following is a copy of instructions issued by Messrs.
Dobson and Barlow, Limited, for erecting, setting, and timing
combers on Heilmann's principle :—

Send all the top rollers to be covered, and scour fluted rollers
and fluted segments ; put the machine in its place and
level it.

Setting cylinders.—Put in the cylinders and set the index
wheel to 5, and with $1\frac{1}{8}''$ gauge between flutes of detaching
roller and front edges of segments make the cylinder fast to the
shaft, and then set the detaching roller flutes to 23's gauge from
flutes on segments.

Distance between flutes of detaching and feed rollers for
Egyptian cotton, $1\frac{13}{16}''$. Long Sea Islands cotton, $2\frac{1}{16}''$.

Distance between flutes of detaching roller and front edge
of cushion plate for Egyptian cotton, $1\frac{3}{16}''$. Long Sea Islands
cotton, $1\frac{7}{16}''$.

Setting nippers.—Put on the cushion plates and set them
up to one thickness of writing paper from nipper knife, and to
$1\frac{3}{16}''$ gauge from flutes of detaching roller to front edge of
cushion plate (the nipper must be open and the stop screws
about $\frac{1}{4}''$ through) ; next set the edge of the knife to 19 or 21's
gauge from cylinder needles, with the right-hand screws only, and
see that the distance between the detaching roller and cushion
plate has not altered (a $\frac{3}{8}$'s gauge must be allowed between the
point of stop screw and nipper stand) ; then set the left-hand

screws by removing the gauge and letting point of screw touch the stand ; then put on the springs. Move the cam round until the bowl is on the circular part, and put the $\frac{3}{8}''$ gauge again between the stop screw and stand, then screw up the nuts on one connecting rod until the gauge is just eased ; now turn the cam round until the screw points are eased from the stands, then turn the cam back again as it was and try the gauge between the knife and cylinder needles, and see that all are quite clear and to gauge.

Set nippers to 19's wire gauge to cylinder needles for Egyptian cotton.

Set nippers to 21's wire gauge to cylinder needles for Sea Islands cotton.

Set top combs to 19's wire gauge to cylinder segment for Egyptian cotton.

Set top combs to 21's wire gauge to cylinder segment for Sea Islands cotton.

Set top combs to an angle of 28 degrees, or to 14's angle gauge.

Setting feed rollers.—For Egyptian cotton with $1\frac{13}{16}''$ gauge between flutes of feed and detaching rollers, make the slides fast, put on the top rollers and springs, and then set the rollers parallel to nipper knife and at a convenient distance from it.

For Long Sea Islands cotton a $2\frac{1}{16}''$ gauge must be used between flutes of feed and detaching rollers.

Setting brushes.—Let the bristles touch the brass of the combs of one cylinder, then make a gauge to go between the brush and cylinder shafts, and set others to this gauge.

Brush tins.—Set them so as to clear the cylinder and doffer about $\frac{1}{8}''$.

Lap plates.—Should be set clear of wood and feed rollers when the clearer brush is on

Lap guides.—Should be set $\frac{1}{4}''$ wider than laps and central with the boss of the feed roller.

Top detaching rollers.—Move the 80's wheel on cam shaft out of gear, and turn round the cam shaft until the quadrant moves forward, then set the index wheel to 6, and put the 80's wheel in gear ; turn the cam shaft round and see that the roller moves forward at 6 ; then clean, oil, and put the brass tubes on the covered top rollers, and put the rollers in, weigh them, let them rest on the segments, and bring up the lifters until the nearest will admit one thickness of paper between it and the tubes (the bowl must be on the highest part of the cam). Then move the small slides on the lifters until each will admit one thickness of paper like the first one, and set the cam so that the roller will touch segment at $6\frac{1}{2}$.

Fluted top detaching rollers.—Should be set with the greatest care, so that the flutes are parallel in the flutes of the bottom roller and quite clear from the leather roller when the same is touching the segment.

Top combs, &c.—For Egyptian cotton set the top combs to 19's gauge from segments of cylinder and to 28 degrees angle or 14's angle of top comb gauge ; for Sea Islands cotton set the top combs to 21's gauge. Put on the sliver plate and gear up all the draw-box, coiler and wood rollers, set the doffer combs and gear up the doffer shaft.

Timing.—

		Egyptian Cotton.	Sea Islands Cotton.
Clutch wheel in gear	at	$\frac{3}{4}$	$\frac{3}{4}$
Feed	,,	5	5
Top comb down	,,	$5\frac{1}{2}$	$5\frac{1}{2}$
Detaching roller forward	,,	6	$6\frac{1}{2}$
Detach	,,	$6\frac{1}{2}$	$6\frac{1}{2}$
Nip	,,	9	$9\frac{1}{4}$

To calculate percentage waste.—Add the weight of waste and cotton together, then multiply the weight of waste by 100, and divide the product by the weight of both waste and cotton,

thus : $\dfrac{\text{waste} \times 100}{\text{waste} + \text{cotton}}$.

Notes.—Be sure that all screws, &c., are well screwed up, and that all bearings are well oiled and the cams well greased, and mind the combs do not get damaged.

The greater the angle of the combs.   Greater the waste.

Later the nipper closes .   .   .   ,,   ,,   ,,

Late feeding .   .   .   .   .   ,,   ,,   ,,

Close setting .   .   .   .   .   ,,   ,,   ,,

Curling is caused by the detaching roller being badly covered or being short of lubrication, and the top covered roller not touching cylinder segment at the proper time ; or top fluted detaching roller not being set perfectly parallel with the flutes of bottom roller.

Setting top comb close to segment and nippers close to cylinder combs means close setting.

The foregoing instructions are suitable for the Duplex Comber in all respects except the setting of nippers and top detaching rollers, and, of course, the timing.

In setting the nippers in a Duplex Comber a $\frac{5}{16}''$ gauge should be used instead of $\frac{3}{8}''$ between the stop screw and nipper stand.

In setting top detaching rollers set the index wheel to $6\frac{3}{4}$ and put the 80's wheel in gear ; turn the cam shaft round and see that the roller moves forward at $6\frac{3}{4}$.   Also, when the slides on the lifters are put in the position stated in the foregoing instructions, set the cam so that the roller will touch segment at $6\frac{3}{4}$.

Production of Comber per head, in $56\frac{1}{2}$ hours.

No. of Nips per Minute	Weight of Lap per Yard	Width of Lap in Inches	Waste per Cent.	Lbs. per Head of Combed Sliver	Kind of Cotton Worked
	dwts.				
80	9	$7\frac{1}{2}$	22	40·2	Sea Islands
—	9	$8\frac{1}{2}$	22	45·5	,,
—	9	9	22	48·24	,,
—--	$9\frac{1}{2}$	$7\frac{1}{2}$	22	42·4	,,
—	$9\frac{1}{2}$	$8\frac{1}{2}$	22	48	,,
—	$9\frac{1}{2}$	9	22	50·8	·,
—	10	$7\frac{1}{2}$	22	44·5	,,
—	10	$8\frac{1}{2}$	22	50·4	,,
—	10	9	22	53·4	,,
—	9	$7\frac{1}{2}$	18	42·2	Egyptian
---	9	$8\frac{1}{2}$	18	47·8	,,
—-.	9	9	18	50·64	,,
—	10	$7\frac{1}{2}$	18	46·8	,,
—	10	$8\frac{1}{2}$	18	53	,,
—	10	9	18	56	,,
—	11	$7\frac{1}{2}$	18	51·5	,,
—	11	$8\frac{1}{2}$	18	58·3	,,
·---	11	9	18	61·8	,,
—	12	$7\frac{1}{2}$	18	56	,,
—-	12	$8\frac{1}{2}$	18	63·4	,,
—	12	9	18	67·2	,,
—-	9	$7\frac{1}{2}$	16	43	American
—	9	$8\frac{1}{2}$	16	48·5	,,
—	9	9	16	51·64	,,
—	10	$7\frac{1}{2}$	16	47·5	,,
—-	10	$8\frac{1}{2}$	16	54	,,
—	10	9	16	57	,,
—-	11	$7\frac{1}{2}$	16	52·5	,,
—	11	$8\frac{1}{2}$	16	59·4	,,
—	11	9	16	63	,,
—	12	$7\frac{1}{2}$	16	57	,,
—	12	$8\frac{1}{2}$	16	64·6	,,
—	12	9	16	68·5	,,

Timing for Duplex Comber.—

		Egyptian Cotton.	Sea Islands Cotton.
Clutch wheel in gear .	at	$4\frac{3}{8}$	$4\frac{3}{8}$
Feed	,,	$4\frac{1}{2}$	$4\frac{1}{2}$
Top comb down . .	,,	$4\frac{1}{2}$	$4\frac{1}{2}$
Detaching roller forward .	,,	$6\frac{3}{4}$	$6\frac{3}{4}$
Detach	,,	$6\frac{7}{8}$	$6\frac{7}{8}$
Nip	͵	9	$9\frac{1}{4}$

Production of Duplex Comber per head, in 56½ hours.

No. of Nips per Minute	Weight of Lap per Yard	Width of Lap in Inches	Waste per Cent.	Lbs. per Head of Combed Sliver	Kind of Cotton Worked
	dwts.				
120	8	$7\frac{1}{2}$	20	52·2	Sea Islands
120	9	$8\frac{1}{2}$	20	59·16	,,
120	9	$7\frac{1}{2}$	18	61·48	Egyptian
120	$10\frac{1}{2}$	$8\frac{1}{2}$	18	73·77	,,
120	9	$7\frac{1}{2}$	18	61·48	American
120	$10\frac{1}{2}$	$8\frac{1}{2}$	18	73·77	,,

Comber Calculations.   *Drafts for comber.* — Before

working the following examples reference should be made to
the general rule given under 'Scutcher Calculations.'

Driving shaft wheel	21 teeth
Cylinder index wheel	80 ,,
Cam shaft wheel	80 ,,
Cylinder wheel	60 ,,
Coiler wheel	59 ,,
Block wheel	40 ,,
Front roller wheel	22 ,,
,, ,, ,, ...	34 ,,
Compound carrier in draw-box . .	$\begin{cases} 40 \text{ ,,} \\ 45 \text{ ,,} \end{cases}$
Large cross shaft wheel	50 ,,
Side shaft wheel	14 ,,
Back roller wheel	50 ,,
Diameter of back roller	$1\frac{3}{8}$ inch
Diameter of bottom block in draw-box .	$2\frac{3}{4}$ inches
Diameter of calender in coiler . .	2 ,,
Coiler driving bevel	22 teeth
Coiler bevel	22 ,,
Star wheel	5 ,,

Cam shaft worm .　　.　　.　　.　　.　　.　Double

Cam shaft worm wheel.　　.　　.　　.　　. 14 teeth

Calender mitre bevels .　　.　　.　　.　　. 20　,,

Diameter of feed roller .　　.　　.　　.　　. $\frac{3}{4}$ inch

Diameter of calender roller .　　.　　.　　. $2\frac{3}{4}$ inches

Feed wheel .　　.　　.　　.　　.　　.　　. 18 teeth

Feed roller wheel .　　.　　.　　.　　.　　. 38　,,

(1) *Draft of draw-box.*—Refer to fig. 84a, and find the plan of the draw-box. Its draft is the ratio of surface speed of the back roller to the surface speed of the calender or delivery
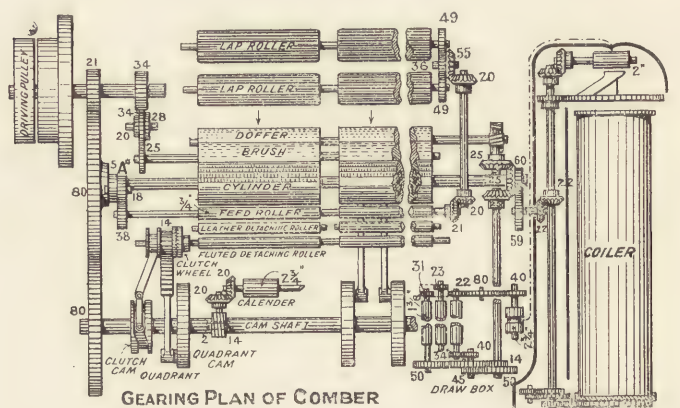
FIG. 84a.—GEARING PLAN OF A PART OF THE COMBER COMBINED WITH SECTIONAL ELEVATION OF COILER AND CAN.

roller. Starting from draw-box driving shaft we find a wheel with 14 teeth driven at a certain speed, say 1. This wheel is geared by carrier into a 50 on the back roller. This latter will have a surface speed of $\frac{41}{50} \times 1\frac{3}{8} \times \frac{22}{7}$. Now work the other way from the same draw-box driving shaft, and find surface

speed of the delivery roller or calender block. Let speed, as before, of shaft be 1. Speed, therefore, of the 45 wheel, which is geared into the 50, will be $\frac{50}{45} \times 1$. Now take the 40 which gears into a 34. It is clear the speed of the latter will be $\frac{4}{34} \times \frac{50}{45} \times 1$. Take next the two wheels which are driven by this 34 wheel, and these are a 22 on the front roller, and a 40 on the block or calender roller. This latter goes $\frac{22}{40}$ times the speed of the 22, or $\frac{40}{34} \times \frac{50}{45} \times \frac{22}{40}$ of 1. The diameter of calender roller is $2\frac{3}{4}''$, surface velocity is $\frac{40}{34} \times \frac{50}{45} \times \frac{22}{40} \times 2\frac{3}{4} \times \frac{22}{7}$.

The draft $= \dfrac{\text{surface velocity of calender roller}}{\text{surface velocity of back roller}}$ or

$$\frac{\left(\frac{40}{34} \times \frac{50}{45} \times \frac{22}{40}\right) \times 2\frac{3}{4}}{\left(\frac{14}{50}\right) \times 1\frac{3}{8}} =$$

$$\frac{22 \times 40 \times 50 \times 50 \times 2\frac{3}{4} \text{ in.}}{40 \times 34 \times 45 \times 14 \times 1\frac{3}{8} \text{ in.}} = 5\cdot13.$$

(2) *Draft from the calender in draw-box to the coiler to be worked in the manner just given—*

$$\frac{40 \times 34 \times 45 \times 60 \times 2 \quad \text{in.}}{22 \times 40 \times 50 \times 59 \times 2\frac{3}{4} \text{ in.}} = 1\cdot02.$$

(3) *Draft from the feed roller to the calender block—*

$$\frac{38 \times 5 \times 2 \times 20 \times 2\frac{3}{4} \text{ in.}}{18 \times 1 \times 14 \times 20 \times \frac{3}{4} \text{ in.}} = 5\cdot52.$$

(4) *Total draft of comber—*

$$5\cdot13 \times 1\cdot01 \times 5\cdot52 = 28\cdot8.$$

(5) *Weight produced.*—What weight will a 6-head comber produce in a week of $56\frac{1}{2}$ hours ? Lap 9 dwts. per yard. 80 nips per minute, machine working 50 hours, $\frac{1}{4}$ inch delivered per head at each nip, waste taken out 20 per cent.

Bring 9 dwts. to grains, 50 hours to minutes, and multiply as shown in the following expression, dividing by 36 to bring to yards, and by 7000 to bring to lbs :—

$$\frac{\cdot 25 \times 80 \times 60 \times 50 \times 216 \times 6}{36 \times 7000} = 308 \cdot 5 \text{ lbs.}$$

$$308 \cdot 5 - \tfrac{1}{5} \text{ for waste}$$
$$= 308 \cdot 5 - 61 \cdot 7 \text{ lbs.}$$
$$= 246 \cdot 8 \text{ lbs. per machine.}$$

(6) *Speed of cylinder.*—If the driving shaft of a combing machine makes 200 revolutions per minute, and has fixed on it a 22-teeth wheel driving an 80 wheel on cylinder shaft, what will be the speed of the cylinder ? Speed will be $\frac{22}{80}$ of 200 thus :—

$$\frac{200 \times 22}{80} = 55 \text{ revolutions per minute.}$$

(7) *Filleting required.*—How many feet of $1\frac{1}{4}''$ wide fillet will be required to cover the doffers of a combing machine, each doffer being $12''$ wide and $5 \cdot 5''$ diameter, and there being 8 heads ?

Length required for strip to go round once $= 5\frac{1}{2}'' \times \dfrac{22}{7}$

No. of strips required $= \dfrac{12}{1\frac{1}{4}} \times 8.$

Total length required in feet $= 5\frac{1}{2} \times \dfrac{22}{7} \times \dfrac{12}{1\frac{1}{4}} \times \dfrac{8}{1} \div 12.$

$$= \frac{5 \cdot 5 \times 22 \times 12 \times 8}{7 \times 1 \cdot 25 \times 12} = 110 \cdot 6 \text{ feet.}$$

(8) *Revolutions of feed roller.*—The cylinder shaft of a

comber makes 70 revolutions per minute. The star wheel as usual contains 5 notches, and is driven by a single stud. The feed change pinion contains 20 teeth, and drives a 44 at the end of feed roller. Find revolutions per minute of feed roller.

$$\frac{70 \times 1 \times 20}{5 \times 44} = 6\cdot36 \text{ revolutions.}$$

(9) *Length of lap delivered.*—If 20″ of lap are fed to one head of a combing machine every minute, how many yards will be fed to the machine in a week of $56\frac{1}{2}$ hours, allowing $6\frac{1}{2}$ hours for stoppages and there being 6 heads? 12 × 3 in the denominator will bring inches to yards.

$$\frac{20 \times 60 \times 50 \times 6}{12 \times 3} = 10{,}000 \text{ yards.}$$

(10) *Comber total draft.*—What is the total draft in a comber if the draft between feed and detaching rollers be 5·5, the draft between detaching rollers and calenders 1·30, and the draw-box draft 3·8?

Rule.—Multiply the three intermediate drafts together—

$$5\cdot5 \times 1\cdot30 \times 3\cdot8 = 27\cdot17 \text{ total draft.}$$

Note.—In all machines the total draft can be found by multiplying the intermediate drafts together, and not by adding them, as students usually imagine is the case at first.

(11) *Production of comber.*—What will be the production in lbs. per week of a Duplex comber with 6 heads making 120 nips per minute and deliver $\frac{1}{4}''$ at each nip; the comber to be actually at work 51 hours, 20% to be allowed for waste, and the laps to weigh 9 dwts. per yard? Get out first lbs. produced thus:

$$\frac{\cdot25 \times 120 \times 60 \times 51 \times 6 \times 9 \times 24}{7000 \times 12 \times 3}.$$

20% is waste, then $\frac{80}{100}$ must be good. Change ·25 thus $\frac{1}{4}$ and multiply as shown in the following operation:—

M

$$\frac{1 \times 120 \times 60 \times 51 \times 6 \times 9 \times 24 \times 80}{4 \times 12 \times 3 \times 7000 \times 100} = 377 \cdot 6 \text{ lbs.}$$

(12) *Ribbon lapper.*—Find revolutions per minute of front roller from particulars given below.

Revolutions per minute of line shaft = 160
Drum on line shaft . . . 20″ diameter
Pulley on frame shaft . . . 14″ „
On same shaft is a wheel . . . 60 teeth
Driving front roller „ . . . 70 „

$$\frac{160 \times 20 \times 60}{14 \times 70} = 193 \cdot 8 \text{ revolutions.}$$

Sliver Lap Machine Calculations. (1) *Weight on calenders* —A 15-lb. weight is hung at the end of a lever 21″ long, the fulcrum being at the opposite end ; $1\frac{3}{4}$″ from the fulcrum the lever puts the weight upon the top calender roller, and the arrangement is employed to weight the other end of the same calender. Find weight on calenders.

$$\frac{15 \times 21 \times 2}{1\frac{3}{4}} = \frac{15 \times 21 \times 2 \times 4}{7} = 360 \text{ lbs.}$$

(2) *Speed of bottom shaft.*—Line shaft 220 revolutions per minute, and there is a pulley on it 9″ diameter driving pulley on bottom shaft of sliver lap machine 16″ diameter. Find speed of bottom shaft.

$$\frac{220 \times 9}{16} = 123 \cdot 7 \text{ revolutions per minute.}$$

(3) *Speed of calenders.*—On the bottom shaft is a 32 wheel driving a 70 on bottom calender roller. Find speed of calenders.

$$\frac{123 \cdot 7 \times 32}{70} = 56 \cdot 5 \text{ revolutions.}$$

(4) *Draft of lap machine.*—One yard of sliver at the back of the sliver lap machine weighs 66 grains, and 14 ends are put

up together. One yard of lap at the front of the machine weighs 19·5 dwts. Find draft in the machine.

66 × 14=weight in grains at back of one yard=924 grains.

19·5 × 24=   ,,   ,,   front   ,,   =468   ,,

Ratio of weight per yard at the feed to weight per yard at the delivery is as 924 : 468, or

$$\frac{924}{468} = 924 \div 468 = 1·97 \text{ draft.}$$

Note.—A small draft is put in this machine chiefly to keep the ends nicely tight and straight, and to slightly assist in laying the fibres parallel.

(5) In sliver lap machine an 18 on front roller of draw-box drives by means of a carrier a 32 on middle roller, and another 32 on this roller drives a 34 back. The diameters of all the rollers being alike, find the draft.

$$\frac{32 \times 34}{18 \times 32} = 1·8 \text{ draft.}$$

Ribbon Lap Machine Calculations. (1) *Speed of bottom shaft.*—The line shaft makes 220 revolutions per minute and contains a 13″ pulley, which drives a 12″ pulley on the end of the bottom or main shaft of ribbon machine. Find speed of bottom shaft. The speed of the latter pulley will be

$$\frac{13}{12} \text{ of } 220 = \frac{220 \times 13}{12} = 238·\dot{3} \text{ revolutions.}$$

(2) *Weight on calenders.*—A weight of 15 lbs. is hung 20½″ from the fulcrum of a lever employed to weight the front conducting or calender rollers of a ribbon machine. The weight devolves on the calenders 2″ from the fulcrum, and this arrangement is employed at either end of the calenders. Find total weight on latter.

$$\frac{20·5 \times 15 \times 2}{2} = 307·5 \text{ lbs.}$$

CHAPTER XIV

Drawing.—The cans containing the slivers are taken from the carding engine or combing machine (as the case may be) to the drawing frame, the object of which machine is mainly to equalise the slivers by combining a number of them together, so as to distribute the fibres uniformly. The condition of the fibres on leaving the card is such that a slight pull will lay them perfectly straight or parallel, and this pull is given by the drawing frame rollers. On the other hand, the fibres composing a sliver from the comber are already laid parallel, but the drawing is as necessary for combed as for carded slivers. The attenuation or drawing of these is part of the work of all the machines between the carding and the spinning.

The drawing frame, a view of which is given in fig 85, is arranged so as to allow of six or eight slivers in cans being fed up to four pairs of drawing rollers, the progressive surface speed of which increases as from 1 to 6 or 8 between the back and front roller. These slivers, or ends, which are as nearly as possible the same weight per yard, are combined together in the drawing, and emerge from the front pair of rollers as one sliver weighing the same number of grains per yard as a single sliver fed up at the back. This process is repeated three or four times, according to requirements, the material then being referred to as having passed through so many ' heads ' of drawing. It is usual to pass Indian and American cotton through three heads or passages, and Egyptian cotton through three or four heads when single carded, but never more than three after combing.

The figure shows the back view of a drawing frame of one head, two deliveries. The cans are omitted, both at the feeding and the delivering side, but the coiler plate on which the cans rest in front of the machine is shown. The guide and spoon levers here are arranged for eight slivers, but six is also a common number in practice. The card cans are put behind
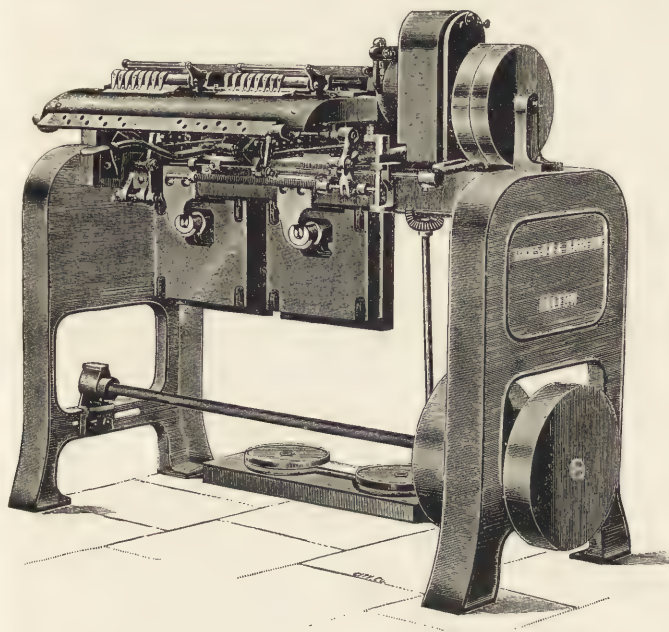

FIG. 85.—DRAWING FRAME OF ONE HEAD, TWO DELIVERIES.

in the most convenient position for feeding. The drawing frames are so placed in the mill as to deliver from the last head near the slubbing frames, in order to avoid unnecessary carrying. The three passages of the material can be accomplished in three different frames, or in one frame (*see* figs. 86 and 87). In fig. 86 it will be seen that the first frame delivers at

the back of the second, and the second at the back of the third. In fig. 87 the material is shown passing through three heads
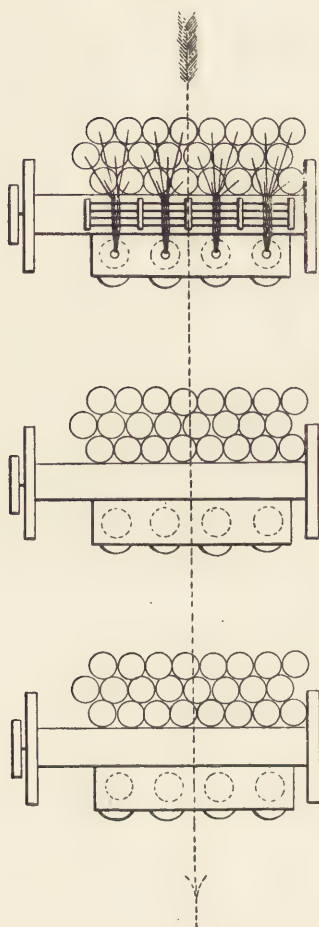
FIG. 86.—PLAN OF DRAWING FRAMES SHOWING POSITION OF CANS WITH STRAIGHT HEADS.
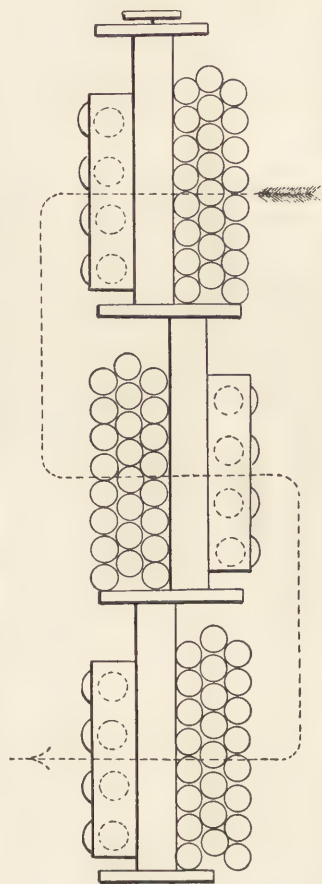
FIG. 87.—PLAN OF DRAWING FRAMES SHOWING POSITION OF CANS WITH CROSSED HEADS.

of drawing in one machine. Both of these arrangements involve a minimum amount of carrying, the progress of the

slivers being shown by arrows. If the foregoing remarks are
followed it will be seen that the combining or intermixture of
the fibres takes place 216 times, because six slivers in the first
head become one, and six of the slivers from the front are
combined in the second head of drawing, to one and six from
the second in the third head to one, thus $6 \times 6 \times 6 = 216$. The
uniformity of the resulting sliver is obtained, because any
irregularity of weight or thickness existing in the card sliver is
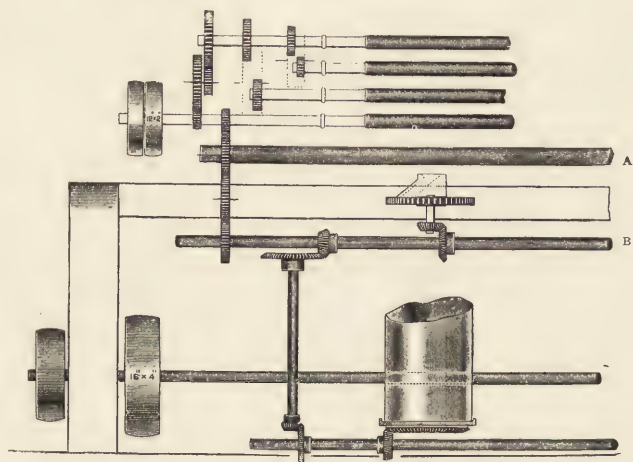
FIG. 88.—SECTION OF GEARING OF DRAWING FRAME WITH PLAN OF ROLLERS.
A. Calender roller 3″ diameter ; B. Coiler shaft.

reduced six times in each passage of drawing rollers. Fig. 88
illustrates how the driving of the various parts is obtained.

The machine is in elevation, but the rollers, which in reality
are horizontal to each other, are shown in plan, so as to show
the gearing of the different lines. The front roller is the
primarily driven one, receiving its motion from the pulley on
the driving shaft. The use of the fast and loose pulley on the
front roller will be seen in treating of the stop motions, as also

the necessity of driving all other parts from the front roller, namely, the calender rollers, coilers, and can shaft, as shown.
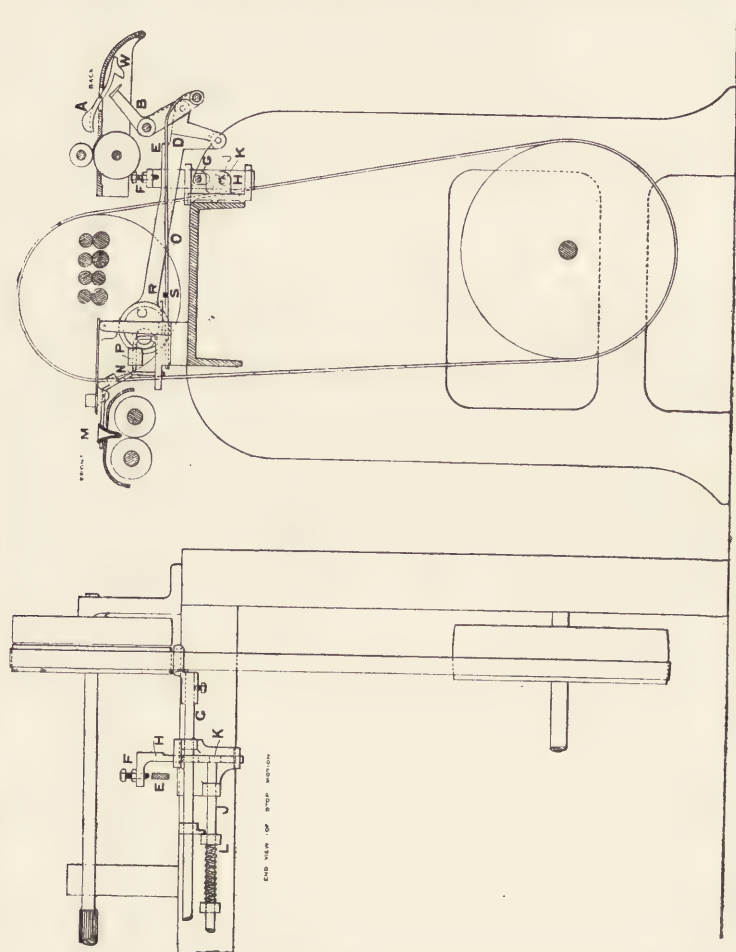

FIG. 89.—SECTIONAL END VIEW OF A DRAWING FRAME WITH FRONT AND BACK STOP MOTIONS.

A sectional end view of a drawing frame with the various automatic stop motions is given in fig. 89. The object of

these is to prevent the occurrence of sliver of diminished thickness from being made when one of the ends breaks down. The stop motions all act on the rod carrying the strap fork, and by stopping the front roller arrest the movement of all other parts.

The various places where an end or sliver may fail can be seen on referring to fig. 89. Each end passes from the guide plate over a balanced 'spoon' lever A, which occupies the position shown so long as the moving sliver keeps it balanced there by depressing it. If the sliver breaks the spoon rises, and its weighted end w drops into the path of a constantly vibrating bar B. This bar receives its vibration from an eccentric C. The link between these two points is jointed at D, and has a shoulder E close to the joint, which is made so as to open when the motion of B is obstructed. When a sliver breaks the motion of B is checked, as explained, and as the eccentric continues to revolve it pulls open the swivel at D, and the shoulder being raised upwards in consequence presses against the screw F and lifts the vertical sliding bracket H, of which it forms a part. The strap rod G passes through a slot in the bracket (*see* both views), and a short shaft J with a spiral spring round it has its end resting against the vertical bracket just above the centre of a round hole K ; consequently when H is lifted upwards the hole K also rises, and the short shaft J is forced through by the spring. The sudden releasing of the spring causes the washer L to carry along with it the strap rod G and strap fork, thus putting the strap from the fast to the loose pulley and stopping the frame. The whole arrangement acts very rapidly. This is called the back stop motion, because it operates when a sliver breaks before reaching the back pair of drawing rollers.

The front stop motion provides against two ways in which spoiled work may be caused. The funnel M is pivoted in the

same way as the spoon lever, being kept in a certain position
during the passage of a sliver of required weight. If from any
cause the sliver becomes lighter than it is intended to be—the
general cause of this defect being roller laps—the funnel rises,
and its weighted tail N is depressed. Its lower extremity then
reaches into the path of a reciprocating rod o called a 'feeler,'
this being moved backwards and forwards from the eccentric c,
as seen in the drawing. The stoppage of the feeler bar then causes
the eccentric rod to pull the joint D open, and the same action
takes place as already explained, and the machine is stopped
until the fault is remedied. The other case in which this
arrangement acts is when the funnel becomes depressed by a
heavy or lumpy sliver, which may be caused by picking up flat
waste. A heavy sliver will force the funnel downwards and its
tail end N upwards ; it catches the end of the weighted lever P,
and tilting it up, brings its extremity R in the way of a screw S,
fixed in the reciprocating feeler, thus arresting the motion
of the latter. The subsequent movements are the same as
before.

Another important motion applied to the drawing frame is
the weight-relieving motion. A most essential requirement in
drawing rollers is the weighting of the top line, because one
pair of rollers must hold the fibres, while the next pair draws
them out by running at an increased speed, and if the top
rollers had no power to hold the slivers it would be impossible
to get proper drawing. The top rollers are covered with
leather, and when the machine is stopped for a length of time
the pressure of the weight will create a flat place on the cir-
cumference of the rollers, unless the weight is relieved (fig. 90).
The full section of a drawing frame shows the end view of the
weights and the hooks by which they are carried on the arbours
of the top rollers. It will be noticed that the weights have each
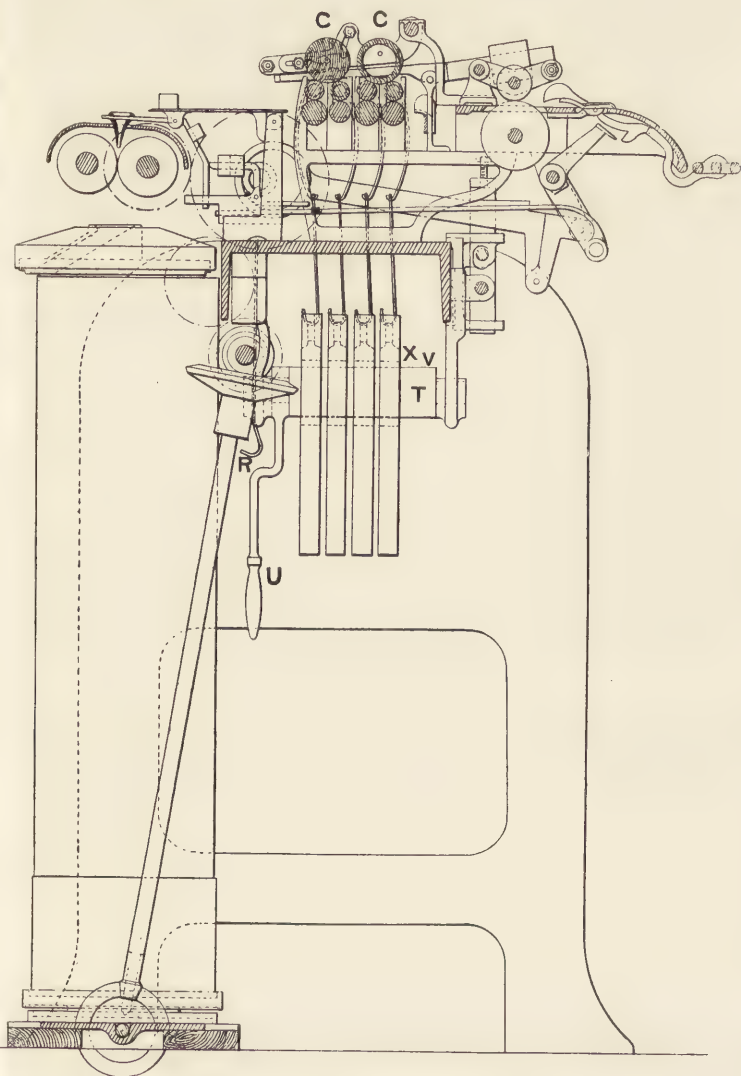a large hole of a certain shape through which passes an eccentric

FIG. 90.—FULL END SECTION OF DRAWING FRAME.

T, which when the frame is at work is out of contact with the weights. The eccentric is supported by brackets at the back and front of the machine. When it is required to take the weights off the rollers the eccentric is turned partly round by means of the handle U, thus bringing the shoulder V in contact with the weights at X and raising them up. The pressure is thus lifted from the rollers and borne by the eccentric, which is kept in this position by placing the handle U inside the wire hook R suspended from the roller beam. There is a separate weight-relieving motion to every delivery in the frame. The rollers are kept free from accumulation of waste or fly by revolving wooden 'clearers' C, which are covered with flannel. Each of the two clearers rests on two lines of rollers, and keeps them clean. They can be readily removed and stripped when requisite.

Calculations on the Draw Frame. (1) *To obtain the speed of the front roller.*—Line shaft speed, say, 220 revolutions per minute. Diameter of the shaft pulley, say, is 11″, and the diameter of the pulley on the frame shaft, say, is 16″. Then the speed of the latter pulley will be $\frac{11}{16}$ of 220, which equals 151·25 revolutions, say 151 revolutions.

The pulley on the frame shaft is 16″ in diameter, and drives one only 12″, and which carries the front roller at the same speed. Therefore the speed of the front roller will be $\frac{16}{12}$ of $\frac{151}{1} = 201 \cdot \dot{3}$, say 201 revolutions per minute. This is the front roller speed.

(2) *To find the draft of the drawing frame.*

Reference to the plan in fig. 92 shows a wheel having twenty teeth driving one with 115 teeth. By means of a compound carrier a wheel having 69 teeth is driven from this.

This wheel drives a 72 wheel on the back roller. On this

back roller is fixed a wheel having 36 teeth, and by means of this a broad carrier having 70 teeth is driven.
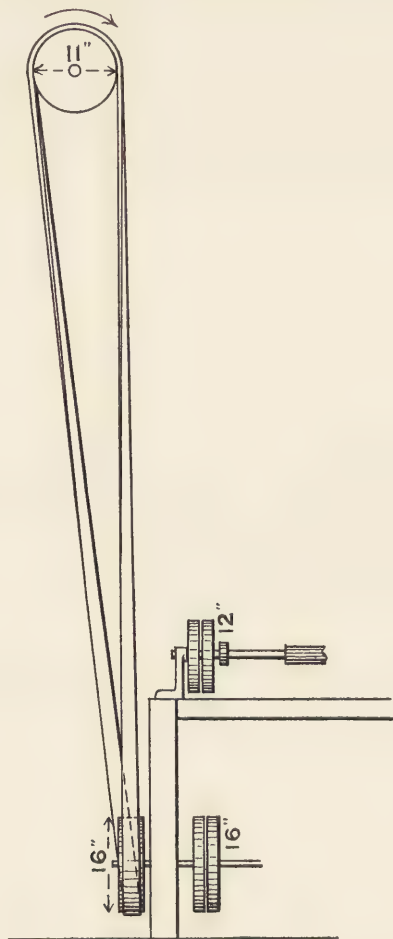

FIG. 91.—VIEW SHOWING DRIVING OF FRONT ROLLER OF DRAWING FRAME.

On the second roller is a wheel with 15 teeth, and this is driven by the wheel having 70 just referred to.

The back roller, again, has a 23 wheel which, by means of a broad carrier, drives a wheel with 52 teeth, and this in turn drives one on the third roller having 18 teeth.

Now suppose that the speed of the 20's wheel on the front roller be 1.

Then the speed of the 115 wheel will be $\dfrac{20}{115}$ of 1, and this represents also the speed of the 69 wheel.
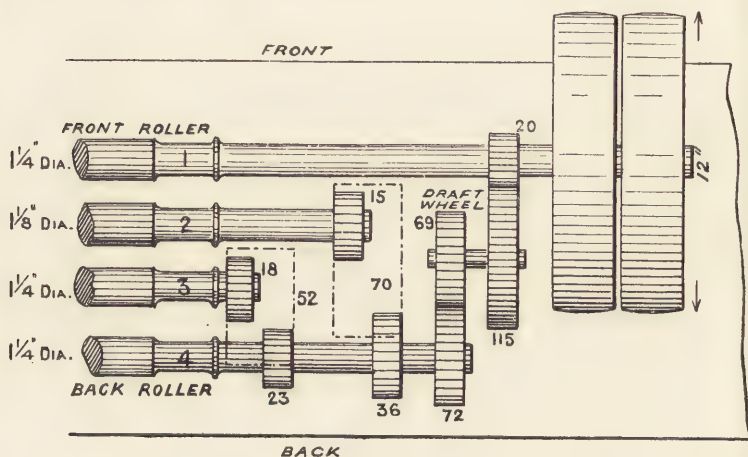
THE DOTTED LINES IN THIS VIEW ARE CARRIER WHEELS.

Fig. 92.—Plan of Gearing for Rollers in Drawing Frame.

The 72 wheel on the back roller is driven from this, and its speed will therefore be $\dfrac{69}{72}$ of $\dfrac{20}{115}$

It should be noted here that, as the diameters of the front and back rollers are the same, this does not affect the calculation $\dfrac{69}{72} \times \dfrac{20}{115} \times 1 = \tfrac{1}{6}$.

In other words, the surface speed of the back roller is one-

sixth that of the front roller, and the ratio in surface speed between the back and the front rollers gives a DRAFT OF SIX in the machine.

Rule.—Multiply the front roller wheel, change wheel and diameter of back roller, and divide this by the product of the crown wheel, back roller wheel, and diameter of front roller.

TO OBTAIN THE INTERMEDIATE DRAFTS.

(3) *To find the draft between the fourth or back roller and the third roller.*

Refer to diagram on preceding page showing plan of rollers, and distinguish between third and fourth rollers.

Let the speed of the fourth roller be represented by 1, and the number of teeth in the back wheel be 23, and that of third roller be 18.

It is clear then that the speed of the third roller wheel, having fewer teeth, will go at a quicker rate than the fourth, or $\frac{23}{18}$ of 1. This = 1·27 of a draft between the fourth and third rollers.

As the diameter of the rollers is the same in each case, we may neglect this in the calculation.

The relative speeds then between fourth and third rollers will be in the ratio of 1 : 1·27.

(4) *To find the draft between the fourth roller and the second roller.*

Proceed exactly as before.

The relative speeds between the fourth and second roller are represented by the wheels on those rollers, viz. 36 : 15, or the wheel on the second roller is going $\frac{36}{15}$ths as fast as the former. This equals 2·6.

But in this case the rollers are of *different diameters*, and allowance must be made for this in calculating the draft.

The diameter of the fourth or back roller is $1\frac{1}{4}''$, and that of the second roller $1\frac{1}{8}''$.

Therefore there will be in this case less production, because the diameter of the second roller is less than the diameter of the back roller, and our terms in this case will be $\dfrac{1\frac{1}{8}}{1\frac{1}{4}}$ of 2·6.

Had the rollers been of the same size in diameter the fraction would have been, say, $\dfrac{1\frac{1}{4}}{1\frac{1}{4}}$ of 2·6, or 2·6 of a draft, but

$\dfrac{1\frac{1}{8}}{1\frac{1}{4}} = \dfrac{9}{10}$. $\therefore \dfrac{9}{10} \times \dfrac{26}{10} = 2\text{·}34$ draft between 4th and 2nd rollers. $\dfrac{22}{7}$ has been disregarded, as it is common to both numerator and denominator.

(5) *To find what pinion is required when altering from one weight in grains to another.*

Say if 100 grains require a pinion of 25 teeth, what pinion will 120 grains require?

In this case 120 grains are required. This means a greater production or a heavier sliver, consequently the wheel must be increased in teeth.

100 grains require 25 teeth, then 1 grain requires $\dfrac{25}{100}$ teeth

and 120 grains require $\dfrac{25 \times 120}{100}$ teeth $= \dfrac{\overset{5}{\cancel{25}} \times \overset{6}{\cancel{120}}}{\underset{\cancel{2}}{\cancel{100}}} = 30$ teeth.

Rule.—Multiply the number of grains required by the change wheel and divide by the number of grains the drawing weighs.

(6) *To find a draft for a drawing frame that will produce a required hank drawing from a given hank carding.*

Rule.—The number of ends put up at the drawing frame multiplied by the hank drawing required and divided by the hank carding will give the draft required.

Example.—If the hank carding be ·18, the number of ends put up 6, the hank drawing required ·21, what draft is required to produce the hank drawing?

Note.—A lighter hank is required, consequently the draft must be greater than the number of ends, viz. 6.

$$\frac{·21 \times 6}{·18} = \frac{1·26}{18}$$
$$= 7 \text{ draft.}$$

(7) *To find the hank carding required to produce a desired hank drawing from a given draft, and the number of ends put up.*

Rule.—The number of ends put up multiplied by the hank drawing and divided by the draft in the draw frame will give the hank carding required.

Example.—Suppose hank drawing required is ·21

,, draft ,, ,, 7

,, number of ends ,, ,, 6

Then $\dfrac{·21 \times 6}{7} = ·18 =$ hank carding required.

(8) *To find the coils deposited in one revolution of the can.*

Upon the size of the coils and their proper disposition in the can depends the compactness of the sliver.

Rule.—Regard the coiler bottom plate as the driver and its speed as one, and find by speed rule the revolutions of the coiler top.

N

Note.—The wheels and dimensions for the following calculation are taken from fig. 93, and approximate to those in general use :

$$\frac{1 \times 104 \times 34 \times 36 \times 20 \times 18 \times 42}{20 \times 10 \times 20 \times 18 \times 20 \times 69} = 19 \cdot 3.$$

The following is a type of calculation which those who do much changing would do well to consider. The method adopted will be apparent from the worked example.
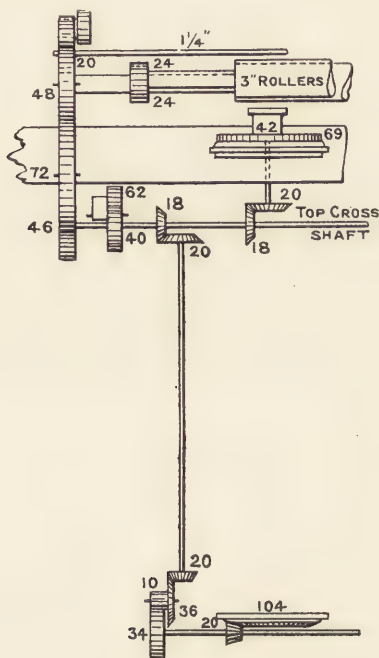

FIG. 93.—View showing Gearing for Coiler Top and Coiler Bottom.

Suppose we deliver a ·12-hank sliver from the card, 6 ends up and 6 of a draft at each head of drawing. We change the hank carding from ·12 to ·17. What will be the draft required

in each of the three heads of drawing, the drafts to be uniform, and to deliver at the last head a ·12-hank sliver ?

$$\sqrt[3]{\frac{6 \times 6 \times 6 \times ·12}{·17}} = 5·34.$$

5·34 should therefore be the draft at each head, whereas it more frequently happens that all the reduction in draft is made at one head, and one frame is made to overrun another. It is necessary to get the cube root, because the uniform draft of 6 is cubed.

Some writers seem inclined to dispute the ability of the draw frame to correct inequalities. We have a very high opinion of its abilities in this direction, and the following calculation is given as showing how the inequalities which always exist in either carded or combed slivers are reduced and almost eliminated by passing through the draw frame.

Suppose we have 8 ends up and 6 of the slivers ·20-hank, which is what we require. Two slivers are ·18-hank, being $\frac{1}{10}$ too coarse.

We get from the first head

$$\frac{(6 \times ·20) + (2 \times ·18)}{8} = ·195.$$

We now pass this along with seven correct slivers through the

second head $\dfrac{(7 \times ·20) + (·195 \times 1)}{8} = ·1993.$

We pass this along with seven correct slivers through the

third head $\dfrac{(7 \times ·20) + (·1993 \times 1)}{8} = ·1999.$

The variation is thus practically eliminated, and although we should never get in actual practice exactly the same result, yet it may be taken as typical of the way variations in weight are reduced.

(9) *To find production of draw frame.*

Rule.—Multiply the revolutions per minute of front roller by its circumference, by the minutes at work, and by the number of slivers delivered. Divide this product by 12 and 3 to bring to yards; 840, to bring to hanks, and by the hank slivers to bring to lbs.

Example.—The front roller of a draw frame is $1\frac{1}{2}$ inches in diameter, and makes 320 revolutions per minute. The frame contains 3 deliveries, and is making a ·20-hank sliver. Find lbs. produced in a week of $56\frac{1}{2}$ hours, allowing $6\frac{1}{2}$ hours for various stoppages.

$$\frac{\frac{320}{1} \times \frac{3}{2} \times \frac{22}{7} \times \frac{60}{1} \times \frac{50}{1} \times \frac{3}{1}}{\frac{12}{1} \times \frac{3}{1} \times \frac{840}{1} \times \cdot 20}$$

$$= \frac{320 \times 3 \times 22 \times 60 \times 50 \times 3}{2 \times 7 \times 12 \times 3 \times 840 \times \cdot 20} = 2244 \frac{44}{49} \text{ lbs.}$$

CHAPTER XV

Flyer Frames.—The next stage in the construction of yarn after the cotton has passed through the drawing frame involves the further attenuation of the sliver, but, as the material has been drawn out almost as much as it is possible without breakage, a small amount of 'twist,' as it is called, is introduced, to allow of the continued drawing out of the sliver.

This double function of drawing and twisting is, therefore, the main object of all succeeding machines until the yarn is fully made. From the drawing frame the sliver, or 'drawing,' passes through two, three, or four flyer frames, according to the class of cotton being worked and its requirements. All these machines are identical in principles and construction, and differ only in the relative sizes of some of the working parts, each successive frame being designed to produce a finer sliver or 'roving,' the latter being the common name for the thread in this stage of its manufacture.

The 'flyer' frames comprise slubbing, intermediate, roving, and jack frames. When two passages of flyer frames only are required, they are the slubbing and roving frames ; if three, the slubbing, intermediate, and roving or jack frames, the last of the three being the rover or jack, usually according to whether the cotton is American or Egyptian. The spinning of these cottons being almost peculiar to certain districts, it may be said that the third flyer frame is described locally as the 'Rover' in Oldham, and as the 'Jack' in Bolton, there being very little distinction between the two. Where very fine counts of
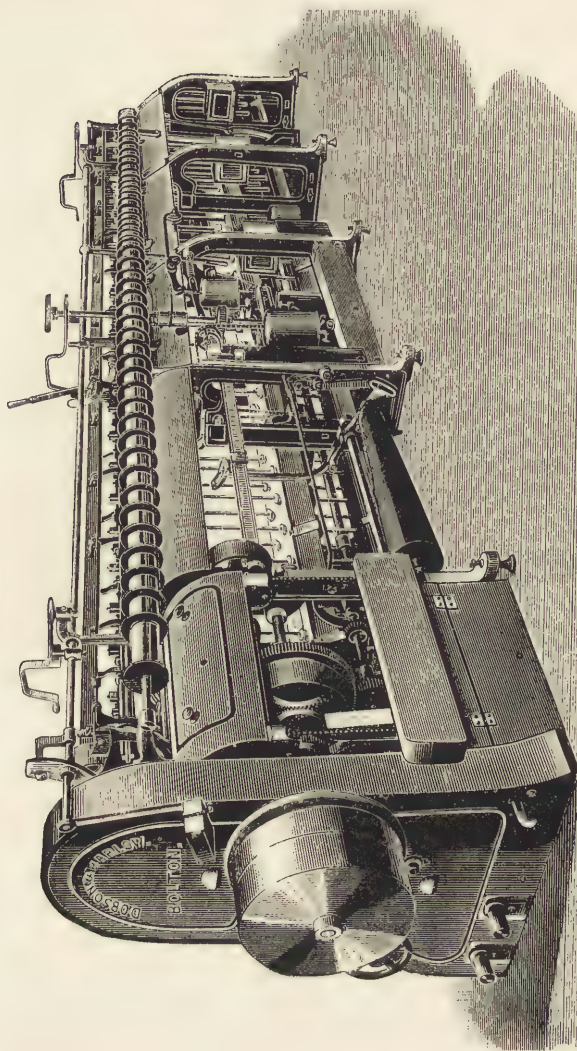
FIG. 94.—BACK VIEW OF SLUBBING FRAME.

yarn are produced, however, the preparation includes the whole of the series, each passage of flyer frame making a finer bobbin of roving. The sliver, in cans from the drawing frame, are thus taken to the slubber in all cases, this machine having no creel for the reception of bobbins. Each sliver is treated separately, there being no combining, as in the drawing frame.

The slubbing frame is illustrated in figs. 94 and 95, the former being a back view, and the latter a front view, of the machine. The ends are conveyed through three pairs of drawing rollers, and, being delivered at the front, are twisted and wound upon bobbins by the flyers, which are fixed on the top of the spindles, and consequently revolve with them. The bobbins are loose on the spindles, and the manner in which the cotton is placed on them will be explained later.

The flyers are each fitted with a presser, the use of which enables a much larger quantity of roving to be wound on the bobbin than was formerly the case, thus causing less doffing, and when the cotton reaches the next flyer frame, less creeling. The creel in which the full bobbins are placed is seen in figs. 96 and 97, the back and front views respectively of a ' Rover.'

The descriptions of the details of flyer frames apply equally to each machine.

The spindles of a frame run at a constant speed, while the bobbin is driven at a continually varying speed as its diameter increases. This necessary condition is accomplished by means of an ingenious differential motion, the common form of which, known as ' Houldsworth's motion,' is shown in fig. 98. The speed of the bobbins must remain uniform during one descent or ascent of the lifting rail, and must diminish at the instant the lift is changed.

The winding-on of the roving is caused by the difference in speed between the bobbin and the flyer, one of which runs faster than the other. If the flyer runs the quicker, it is said

to lead, and if the bobbin runs the quicker, the bobbin leads. Both run in the same direction. When the bobbin leads the
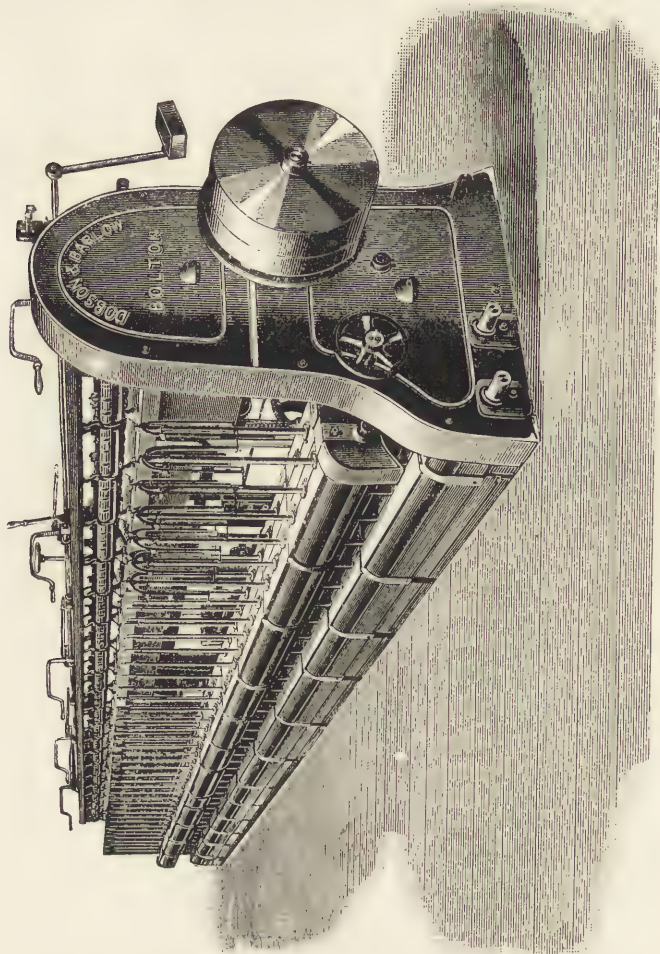

FIG. 95.—FRONT VIEW OF SLUBBING FRAME.

velocity of the bobbin has to be gradually diminished as its diameter increases, to prevent the roving being stretched,
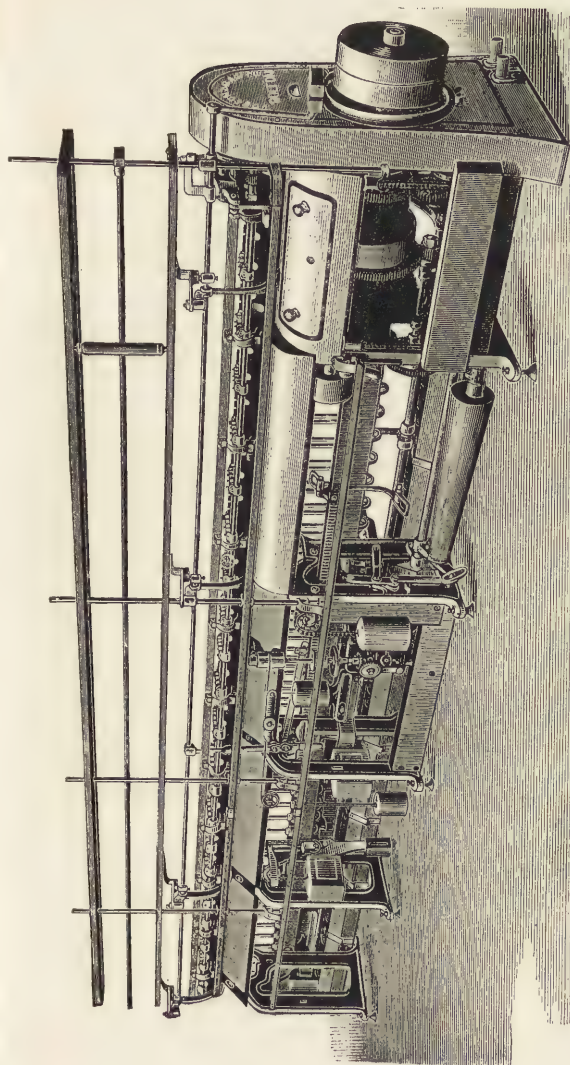
Fig. 96.—Back View of Roving Frame.

because the speeds of the spindles and rollers do not vary.   If
the flyer leads the bobbin speed has to be increased.   In either
case, however, the speed of the lifting rail carrying the bobbins
has to be diminished gradually throughout the set.   The
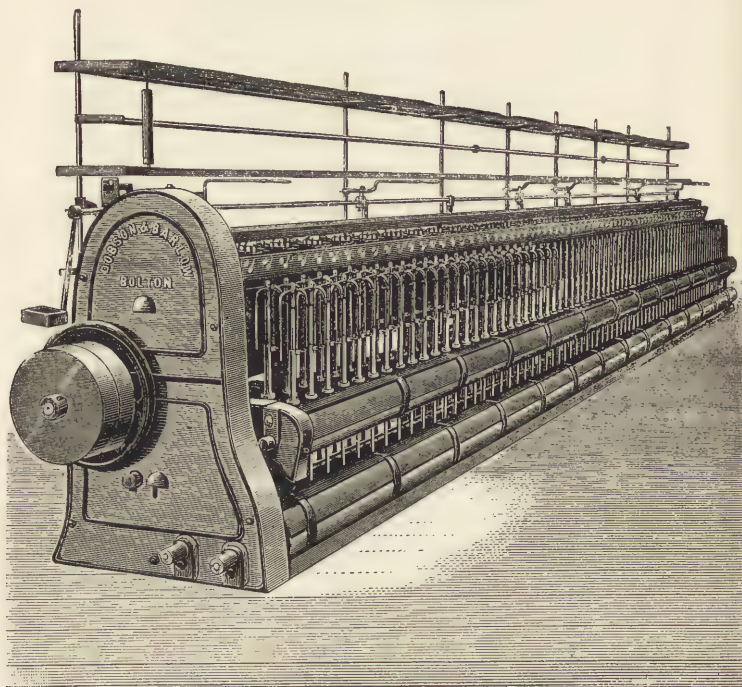
FIG. 97.—FRONT VIEW OF ROVING FRAME.

spindles and bobbins are driven independently of each other
by bevel wheels, a method which ensures an uniform speed for
every spindle and allows the bobbin speed to be readily varied.

The elevation (fig. 98) shows the gearing of a flyer frame,
including the driving of rollers, spindles, bobbins, and lifting
and reversing arrangements.   The drawing rollers are turned
up to place them in plan, so as to show at a glance the way in

which the middle and back lines are driven from the front, and
also the method of altering the draft. The main shaft, with
fast and loose pulleys, supplies motion to the spindles and
flyers through the wheel B, the large carrier, and the spindle
shaft, this speed being unalterable except by changing the
pulleys. This driving shaft passes through the long boss of the
differential motion, and carries the bevel wheel C and the twist
wheel D, both of which are set-screwed on to it, and revolve at
a constant speed during the making of a set. The twist wheel
D drives the top cone drum shaft and the rollers, and is
changed only when the amount of twist in the roving—that
is, the number of turns per inch—is required to be in-
creased or decreased. The draft wheel A, another change
place, is intended to alter the extent to which the material is
drawn out—in other words, the draft. The upper, or concave
drum, drives the lower, or convex drum, by means of the belt
shown. It is evident that when the belt is on the large end of
the driving cone the driven cone will run at its greatest speed, and
when moved to the right as far as possible the lower drum will
be at its slowest speed. The reason for the cone drums being
concave and convex will be clear from the following explana-
tion :—Let $\frac{1}{8}''$ be added to an empty bobbin of $1\frac{1}{8}''$ diameter.
Then it has been increased by $\frac{1}{10}$th part of the whole ; whereas
$\frac{1}{8}''$ added to a full bobbin of $4''$ diameter only increases that
diameter by $\frac{1}{33}$rd part of the whole. The '*Winding Revolutions*,'
and consequently the revolutions of the convex cone, must be
diminished in the same ratio, and this is done by making each
inch in length of the cones to give a less variation in diameter than
the preceding inch, necessarily resulting in the concavity and con-
vexity of the drums. Fig. 98 shows the direction of the driving
shaft by an arrow. In addition to the wheel B and twist wheel,
the bevel wheel C is keyed fast to the shaft and revolves in the
same direction. The large wheel E, called the sun wheel, has

SECTION OF GEARING FOR FLY FRAMES.

BACK ROLLER

MIDDLE ROLLER

FRONT ROLLER

CROWN WHEEL

A DRAFT WHEEL

BOBBIN WHEEL

LIFTING SHAFT

SPINDLE SHAFT

STRIKE SHAFT

TWIST WHEEL

JACK SHAFT
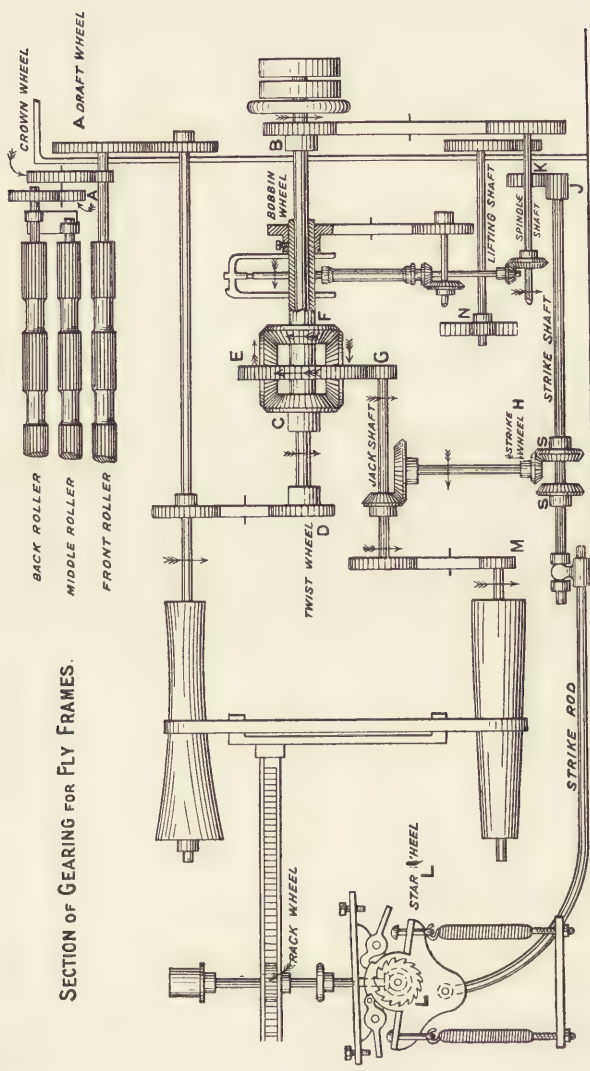
STRIKE WHEEL H

STAR WHEEL

RACK WHEEL

STRIKE ROD

Fig. 98.—SECTIONAL ELEVATION OF FLY FRAME AND PLAN OF ROLLERS.

two flanges, each of which carries a mitre bevel. These act as carriers to convey motion from the fast wheel c to the bobbin wheel, because the fourth mitre f is fixed on the same loose boss as the bobbin wheel. This combination provides that, although the four bevels each contain the same number of teeth, the speed given to the bobbin wheel f varies from that of c. Suppose the wheel c was kept motionless whilst the sun wheel made one full revolution, the bobbin wheel would make two, because the sun wheel carries its two mitres round with it. If, however, the sun wheel were at rest whilst c revolved, the speed of the wheel f would be exactly the same as c, but in the contrary direction. Therefore when all the motion is at work the 'gain' in the wheel f and the bobbin wheel is two revolutions over and above that of c for every revolution made by the sun wheel. The sun wheel is driven by the wheel g on the jack shaft, its connection with the cone being clearly shown. These cones do not actually drive the bobbins, but simply increase or decrease their speed as required. The effect of this motion will be seen immediately. The jack shaft drives, by means of the bevel shown on it, the vertical shaft carrying the strike wheel h. This strike wheel engages with one or the other of two bevels on the strike shaft, each change causing the direction of the latter to be changed. The reversing of the strike shaft causes the bobbin rail to ascend or descend. During this movement, the extent of which is known as the 'lift,' the bobbins slide upon the spindles, whilst the flyer continues to revolve in one horizontal plane. A broad pinion j on the end of the strike shaft constantly gears with a wheel k carried on a short shaft not seen in the elevation. This shaft drives in the manner shown the lifting shaft, which carries the lifter wheel n. The lifter wheel engages with the rack, and the latter, forming part of the bobbin rail, causes the bobbins to be moved up or down according to the direction of the strike shaft.

The alternate engagement of the two bevels on the strike shaft
is controlled by the builder motion, which is seen on the left
hand of fig. 98, and in more detail in figs. 99 and 100. This
contrivance also regulates the movement of the cone belt.
There are two oscillating cradles R and S, the lower of which is
connected by two springs to a swinging beam T. The latter is
in contact with the V- shaped projection of a large rail W, the
use of which will be seen later. Referring now to fig. 100, it
will be seen that the upper tumbler R is connected to the
lower one S by means of hooks passing through both of them
and held by springs in the swing beam T. At the point where
the lower cradle is centred, a small pinion N (fig. 99), gearing with
a rack, is supported, and on the front of the same (*see* fig. 100)
is placed the star wheel G, which is acted upon by two long
catches H and J. Below this point in the centre of the stand
is another centre, A¹, containing a pin, which, being connected
to the strike rod K, controls the striking bevels.

Now the rack L, known as the shortening or diminishing
rack, and which engages with the small pinion N, is connected
by a stud P to a long slotted bracket or slide M (fig. 99), which
is a very important part of the apparatus for shortening the
traverse of the bobbins at every lift. The slide moves up and
down with the bobbin rail, and consequently gives an oscilla-
tory movement to the shortening rack. The latter passes
through two bearings in the upper tumbler R, as shown, and
when R is depressed by its action, the set screws V come down
upon the pigeon levers A and B, and force them to move. The
two pigeon levers A and B, which are connected by a chain, have
alternately their noses in contact with shoulders formed on the
upper portion of the tumbler S. On the same centre as the
star wheel is a small bevel driving another on the upright shaft
(*see* fig. 99). These wheels have the same number of teeth, and
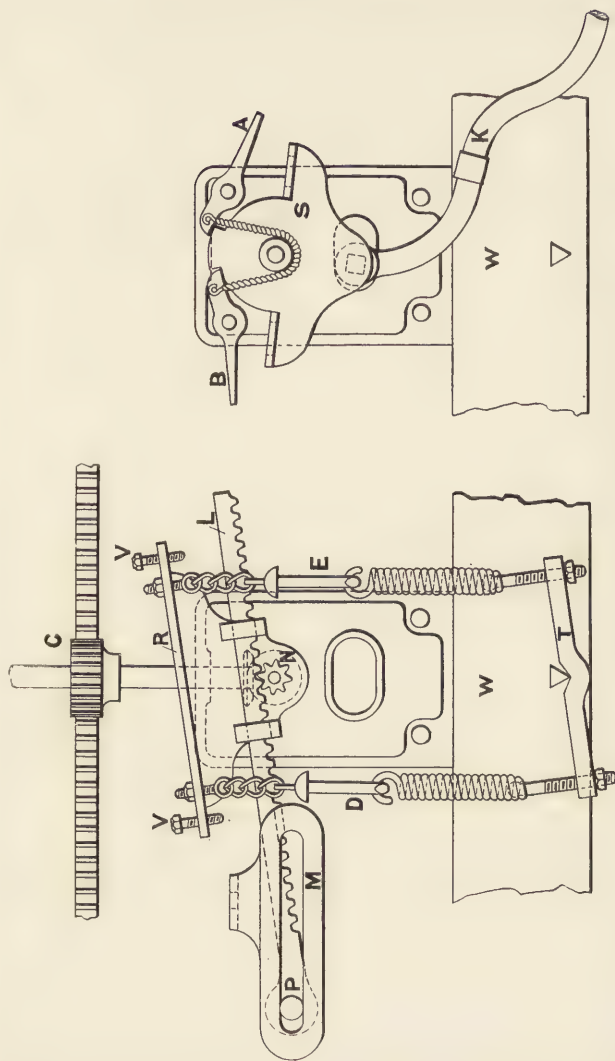consequently the upright shaft and the rack wheel C make one

Fig. 99.—Elevation of Builder Motion of Fly Frame.

revolution in the same time as the star wheel G. It is now
evident that when the bobbin rail descends the slide M also
descends, and causing the shortening rack to oscillate, depresses
one end of the tumbler R. Accordingly the hook E rises and
slides through the hole in the lower tumbler, whilst the hook
D falls, thus relieving the pressure on that arm of the tumbler
S. Then the nose of the pigeon checks the turning of s until
the set screw comes upon its tail and releases it by causing its
disengagement with the shoulder. The sudden movement of
the tumbler s thus made carries the star wheel free from one
catch, J, which, being connected by a spring to the other catch,
H, prevents the star wheel from moving more than half a tooth
before it is arrested by H. This movement takes place once
for each oscillation of the shortening rack, and it is communi-
cated to the rack wheel, which moves the belt on the cone
drum. On consulting fig. 98 it will be plainly seen that the
same action of the tumbler gives a longitudinal motion to the
strike rod, and throws the other bevel into gear with the strike
wheel. The partial revolution of the star wheel G is also
accompanied by a similar movement of the small pinion N,
which gears with the shortening rack. This reduces the
distance between the centre of the pinion and the pin in the
slide, with the result that each succeeding oscillation takes
place quicker than the last, which is the object desired in
order to decrease the lift and shape the bobbin.

Fig. 101 is a diagram showing the wheels connecting the
strike shaft and the lifting shaft, and the cone drums and the
jack shaft.

There are altogether six change places in the gearing of
a flyer frame, but only four of them are usually requisite once
the frame is erected and at work. The first of these is the
draft wheel A (fig. 98), the use of which has already been
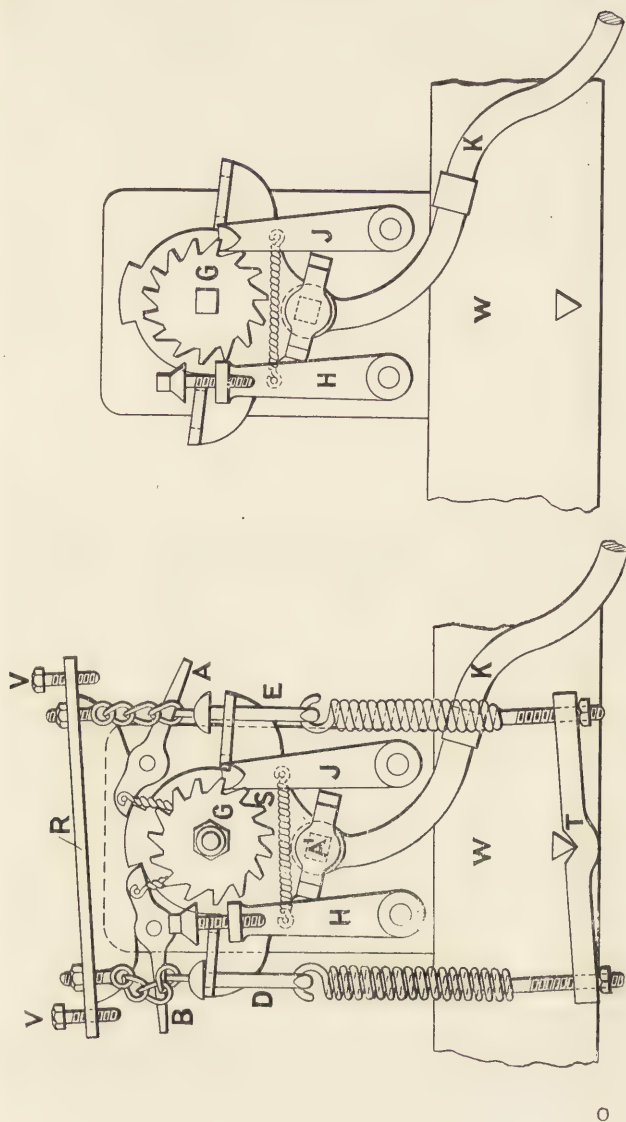explained in treating of other machines. The second is the

FIG 100.—ELEVATION OF BUILDER MOTION OF FLY FRAME.

twist wheel D, which, when changed, alters the speed of the top cone drum shaft, and changes the number of turns of front roller relatively to the spindles. The star wheel L regulates the winding—that is, the tightness or slackness of the roving on
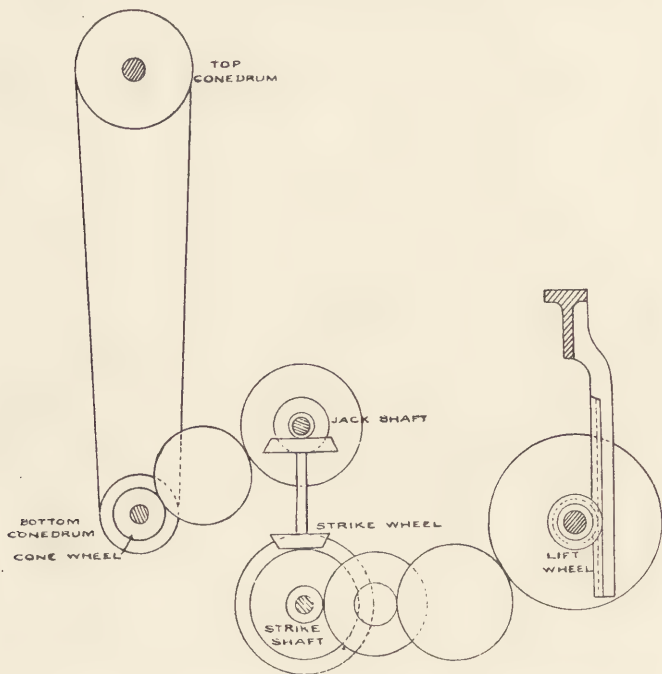

Fig. 101.—Gearing Arrangement of Fly Frame showing Connections between Cone Drum, Jack Shaft, Strike Shaft, and Lifting Shaft.

the bobbins. When it is changed the motion of the belt along the cones is made quicker or slower. The strike wheel, or lifter wheel, H, decides the pitch of the coils on the bobbin by lifting the bobbin rail quicker or slower, as desired.

The jack wheel G, which is said to be proportional to the diameter of empty bobbin, governs the speed of the bobbins

by driving the sun wheel. It is itself driven from the bottom cone drum, and is very seldom changed, except when the diameter of the bobbin is altered.

The cone wheel M is the last change place. It is the least important, and is scarcely ever altered at all. On it depends the traverse and diameter of the bobbin, so that when the machine is once started the cone wheel is seldom disturbed.

An example of the changes required to be made, as a rule, is afforded when, for instance, the hank bobbin produced by a frame is altered without putting a different hank roving in the creel. Let it be intended to produce a finer hank bobbin than the one now being made from the same roving in the creel.

1st.—The draft wheel must be altered to a less number of teeth, thus reducing the speed of the back roller. A less amount of roving will be taken in, and therefore the front roller will deliver a thinner or finer roving.

2nd.—The twist wheel must be altered to a less number of teeth, so as to slower the rollers and put more twist in the roving.

3rd.—The star wheel must be altered finer, that is, it must have more teeth on it, so as to make the traverse of rack and cone belt less at each lift of the bobbin rail. This is because the coils are thinner, and more length will be put on the bobbins.

4th.—The strike, or lifter, wheel must be altered to a less number of teeth, so as to lift the bobbin rail slower, because the roving is thinner, and more coils will be put on the bobbins.

The foregoing descriptions include all the principal parts of the flyer frames and their functions. It is hardly necessary to state that different makers have slightly different methods of obtaining the required results, but the general principles of each motion are identical in all frames.

There are, for instance, several well-known forms of differential motion in use, one of the latest, and probably the most serviceable, being that made by Messrs. Dobson and Barlow, Limited.

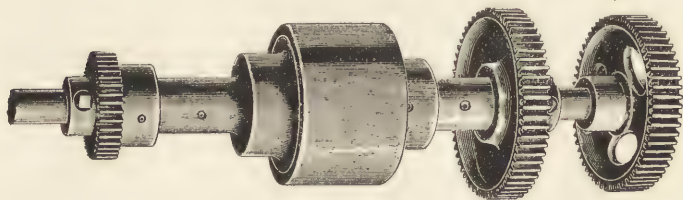It is illustrated in fig. 102, and in full elevation in

FIG. 102.—VIEW OF DIFFERENTIAL MOTION OF FLY FRAME.

fig. 103. The driving shaft A has fixed upon it a bevel wheel B, gearing into and driving another larger one C. The latter is an oscillating bevel, mounted on a spherical bearing D, which runs loosely in the same direction. The wheel C also gears into another bevel wheel S, fixed on the spherical bearing.

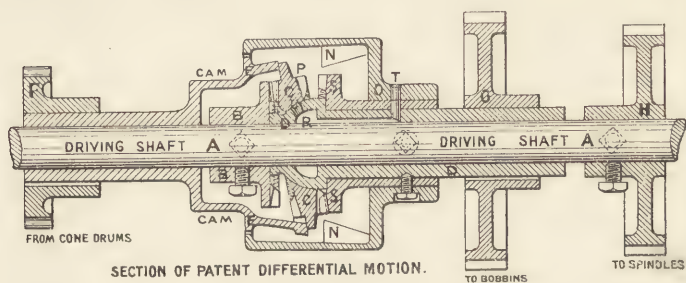SECTION OF PATENT DIFFERENTIAL MOTION.

FIG. 103.—SECTION OF DIFFERENTIAL MOTION OF FLY FRAME.

This bevel S controls the bearing and long collar, and any alteration which takes place in the speed of S is communicated to the bobbin wheel and the bobbins. The change of speed imparted to the motion is communicated from the cone drums by means of a cam E, with an inclined surface, which

bears against the rim of the wheel c. This cam runs loose
on the driving shaft and in the same direction ; its face serves
to keep the wheels in gear, and, by controlling the gearing
point, determines the ratio of speed between the spindles and
bobbins. If b is revolved, c will also revolve with it, as a pair
of clutch wheels, and at the same speed. At the same time
the cam e is arranged to run at the same speed as the wheel c ;
thus b and c and the cam are all the same in direction and
speed at the beginning of a set ; at this time the bobbin will
run at the correct speed for winding on, that is, quicker than
the spindles, but this speed must be gradually reduced to
prevent stretching as each succeeding layer is put on the
bobbins. The strap is moved along the cones towards the
large end of the bottom cone, which of course slowers the
wheel f and the cam, and, as the cam governs the point of
contact of the two bevels b and c, it necessarily follows that
immediately the speed of the cam is reduced this point of
contact moves backwards in the opposite direction to the
driving shaft. The rolling motion thus produced, and which
is the object of the spherical bearing, slowers the bevel c, and
this reduction is communicated to the bobbin wheel G, and
diminishes the speed of the bobbins.

The section in fig. 103 shows the perfect system of lubricat-
ing the whole of the motion. The oil is put at t, where it oils
the driving shaft, and by means of the recess in the boss of
the spherical bearing flows into the chamber r ; from here it
lubricates the bearing d by means of an oil hole, and also
reaches the wheel teeth on both sides of c. The casing o
prevents the oil from escaping when the machine is stopped,
and on restarting the oil is again distributed by the projections
n. The casing also prevents dirt or cotton from reaching the
working parts, and, in addition, there is no chance of injury to
the attendant through carelessness.

PRODUCTION OF SLUBBING FRAME
INDIAN COTTON

Diameter of front roller, $1\frac{1}{4}$ inches.   Working hours of mill, $56\frac{1}{2}$.

Revolutions of Spindles	Turns of Spindle for 1 of Front Roller	Revolutions of Front Roller	Hank roving	Hanks per Spindle	Lbs. per Spindle
550	$3\frac{3}{4}$	146	$\frac{1}{2}$	49·77	99·54
	4	137·5	$\frac{5}{8}$	46·6	74·5
	$4\frac{1}{8}$	133	$\frac{3}{4}$	45·23	60
	$4\frac{1}{4}$	129·4	$\frac{7}{8}$	43·8	50
	$4\frac{3}{8}$	118	1	42·6	42·6

PRODUCTION OF INTERMEDIATE FRAME
INDIAN COTTON

Diameter of front roller, $1\frac{1}{4}$ inches.   Working hours of mill, $56\frac{1}{2}$.

Revolutions of Spindles	Turns of Spindle for 1 of Front Roller	Revolutions of Front Roller	Hank roving	Hanks per Spindle	Lbs. per Spindle
700	$4\frac{3}{4}$	147·3	1	54	54
	$5\frac{1}{2}$	127·4	$1\frac{1}{4}$	46·5	37·2
	$6\frac{1}{4}$	112	$1\frac{1}{2}$	41	27·33
	7	100	$1\frac{3}{4}$	37·3	21·3
	$7\frac{1}{2}$	93·3	2	34·2	17·11
	8	87·5	$2\frac{1}{2}$	32	12·8
	$8\frac{1}{4}$	84·8	3	31	10·33

PRODUCTION OF ROVING FRAME
INDIAN COTTON

Diameter of front roller, $1\frac{1}{8}$ inches.   Working hours of mill, $56\frac{1}{2}$.

Revolutions of Spindles	Turns of Spindle for 1 of Front Roller	Revolutions of Front Roller	Hank roving	Hanks per Spindle	Lbs. per Spindle
1,050	7·25	144	$1\frac{3}{4}$	50	27·4
	7·5	140	2	49	24·5
	7·75	135·4	$2\frac{1}{4}$	47	20
	8·125	129	$2\frac{1}{2}$	45	17·34
	8·5	123·5	$2\frac{3}{4}$	42·8	15
	9	116·6	3	40·8	13·6
	9·5	110·5	$3\frac{1}{2}$	38·3	10·57
	9·8	107	$3\frac{3}{4}$	37	9·59
	10·2	102·9	4	35·75	8·65

PRODUCTION OF SLUBBING FRAME
AMERICAN COTTON
Diameter of front roller, $1\frac{1}{4}$ inches.   Working hours of mill, $56\frac{1}{2}$.

Revolutions of Spindles	Turns of Spindle for 1 of Front Roller	Revolutions of Front Roller	Hank roving	Hanks per Spindle	Lbs. per Spindle
470	3	156	$\frac{3}{8}$	53	141
	3	156	$\frac{1}{2}$	53	106
	$3\frac{1}{8}$	150	$\frac{5}{8}$	51	81·6
	$3\frac{1}{4}$	144	$\frac{3}{4}$	49	65·3
	$3\frac{1}{2}$	134	$\frac{7}{8}$	45·8	52·3
	$3\frac{3}{4}$	125	1	42·7	42·7
	4	117	$1\frac{1}{8}$	40	35·5
	$4\frac{1}{4}$	110	$1\frac{1}{4}$	37·6	30

PRODUCTION OF INTERMEDIATE FRAME
AMERICAN COTTON
Diameter of front roller, $1\frac{1}{4}$ inches.   Working hours of mill, $56\frac{1}{2}$.

Revolutions of Spindles	Turns of Spindles for 1 of Front Roller	Revolutions of Front Roller	Hank roving	Hanks per Spindle	Lbs. per Spindle
700	$4\frac{3}{4}$	147	1	54·8	54·8
	5	140	$1\frac{1}{4}$	52	41·6
	$5\frac{3}{8}$	130	$1\frac{1}{2}$	48·5	32·3
	$5\frac{7}{8}$	119	$1\frac{3}{4}$	44·4	25·37
	$6\frac{1}{4}$	112	2	41·8	20·9
	$6\frac{3}{4}$	103	$2\frac{1}{2}$	38·4	15·36
	7	100	3	37	12·33

PRODUCTION OF ROVING FRAME
AMERICAN COTTON
Diameter of front roller, $1\frac{1}{8}$ inches.   Working hours of mill, $56\frac{1}{2}$.

Revolutions of Spindles	Turns of Spindles for 1 of Front Roller	Revolutions of Front Roller	Hank roving	Hanks per Spindle	Lbs. per Spindle
1,050	7	150	2	53·6	26·9
	$7\frac{1}{4}$	144	$2\frac{1}{4}$	51·4	22·4
	$7\frac{5}{8}$	142	$2\frac{1}{2}$	50·7	20·28
	$7\frac{1}{2}$	140	$2\frac{3}{4}$	50	18·18
	$7\frac{3}{4}$	136	3	48·5	16·16
	$8\frac{1}{4}$	127	$3\frac{1}{2}$	45·3	12·9
	$8\frac{5}{8}$	121	$3\frac{3}{4}$	43	11·46

PRODUCTION OF ROVING FRAME (*continued*)

Revolutions of Spindles	Turns of Spindles for 1 of Front Roller	Revolutions of Front Roller	Hank roving	Hanks per Spindle	Lbs. per Spindle
	$8\frac{7}{8}$	118	4	42	10·5
	$9\frac{1}{8}$	115	$4\frac{1}{4}$	41	9·6
	$9\frac{1}{2}$	110	$4\frac{1}{2}$	39·29	8·7
	$9\frac{3}{4}$	107	5	38·22	7·64
	10	105	$5\frac{1}{2}$	37·5	6·8
	$10\frac{1}{2}$	100	6	35·7	5·95
	$10\frac{3}{4}$	97	$6\frac{1}{2}$	34·6	5·3
	11	95	7	33·9	4·8

PRODUCTION OF SLUBBING FRAME
EGYPTIAN COTTON
Diameter of front roller, $1\frac{3}{8}$ inches.   Working hours of mill, $56\frac{1}{2}$.

Revolutions of Spindles	Turns of Spindle for 1 of Front Roller	Revolutions of Front Roller	Hank roving	Hanks per Spindle	Lbs. per Spindle
400	2·5	160	$\frac{1}{2}$	60	120
	2·65	150	$\frac{5}{8}$	56	89·6
	2·75	145	$\frac{3}{4}$	54	72
	2·85	140	$\frac{7}{8}$	52	59·4
	3	133	1	49·9	49·9
	3·25	123	$1\frac{1}{8}$	46	40·8
	3·5	114	$1\frac{1}{4}$	42·7	34·16
	3·65	109	$1\frac{1}{2}$	40·9	27·26

PRODUCTION OF INTERMEDIATE FRAME
EGYPTIAN COTTON
Diameter of front roller, $1\frac{1}{4}$ inches.   Working hours of mill, $56\frac{1}{2}$.

Revolutions of Spindles	Turns of Spindle for 1 of Front Roller	Revolutions of Front Roller	Hank roving	Hanks per Spindle	Lbs. per Spindle
650	5·18	125	$2\frac{1}{2}$	46·6	18·64
	5·25	123·8	3	46	15·33
	5·5	118	$3\frac{1}{2}$	44	12·57
	5·75	113	$3\frac{3}{4}$	42	11·2
	6	108	4	40·3	10·075
	6·25	104	$4\frac{1}{4}$	38·8	9·17
	6·5	100	$4\frac{1}{2}$	37·3	8·28

PRODUCTION OF JACK FRAME
EGYPTIAN COTTON

Diameter of front roller, $1\frac{1}{4}$ inches.   Working hours of mill, $56\frac{1}{2}$.

Revolutions of Spindles	Turns of Spindle for 1 of Front Roller	Revolutions of Front Roller	Hank roving	Hanks per Spindle	Lbs. per Spindle
1,050	9	116·6	8	47	5·875
	$9\frac{1}{2}$	110·5	9	44·6	4·95
	10	105	$9\frac{1}{2}$	42·4	4·46
	$10\frac{1}{2}$	100	10	40·4	4·04
	$10\frac{3}{4}$	97·6	$10\frac{1}{2}$	39·3	3·74
	11	95	11	38·4	3·49
	$11\frac{1}{2}$	92	$11\frac{1}{2}$	37	3·21
	12	87·6	12	35·4	2·95
	$12\frac{1}{2}$	84	13	33·9	2·6
	$13\frac{1}{2}$	77·7	14	31·4	2·24
	14	75	15	30·2	2
	$14\frac{1}{2}$	72	16	29	1·8

Setting of Drawing Roller.—The distances from centre to centre of the rollers of drawing and spinning machines depend on four conditions, namely, the length of the fibres, the thickness of the sliver or 'roving' to be operated on, the quantity of twist in the roving, and the amount of the draft.   The first point is the most important, that is, the length of the fibre. It is necessary to make the distance from the nip or centre of one pair of rollers to that of the next slightly in excess of the mean length of the staple, in order to avoid breaking, by means of the quicker running pair drawing a fibre that is still held by the preceding pair.   It is equally as important to keep the same distance from becoming too wide, which would allow the fibres to escape the influence of the rollers and make draft impossible. It therefore follows that the longer the staple of the cotton, and the further apart the lines of rollers must be placed, the same thing affects the diameters of the drawing rollers, because a long cotton will admit rollers of a large diameter, on account of

	Diameters of Bottom Rollers				Diameters of Top Rollers				Distances		
	Front	Second	Third or back	Fourth or back	Front	Second	Third or back	Fourth or back	Front to second	Second to third or back	Third to fourth or back
	inch	inch	inch	inch	inch	inch	inch	inch	inch	inch	inch
Indian Cotton											
Draw Frame . . .	$1\frac{1}{8}$	1	$1\frac{1}{8}$	$1\frac{1}{8}$	$\frac{7}{8}$	$\frac{7}{8}$	1	$\frac{7}{8}$	$1\frac{1}{8}$	$1\frac{1}{4}$	$1\frac{1}{16}$
Slubber . . .	$1\frac{1}{8}$	$\frac{7}{8}$	$1\frac{1}{8}$		$\frac{7}{8}$	$\frac{7}{8}$	$\frac{7}{8}$		$1\frac{1}{16}$	$1\frac{3}{16}$	
Intermediate . .	$1\frac{1}{8}$	$\frac{3}{4}$	$1\frac{1}{8}$		$\frac{7}{8}$	$\frac{7}{8}$	$\frac{7}{8}$		1	$1\frac{1}{8}$	
Rover . . .	1	$\frac{3}{4}$	1		$\frac{13}{16}$	$\frac{13}{16}$	$\frac{13}{16}$		1	$1\frac{5}{16}$	
Mule-double boss . .	$\frac{7}{8}$	$\frac{3}{4}$	$\frac{7}{8}$		$\frac{11}{16}$	$\frac{11}{16}$	$\frac{11}{16}$		$\frac{7}{8}$	$1\frac{1}{2}$	
Throstle . . .	$\frac{7}{8}$	$\frac{1}{2}$	$\frac{3}{4}$		$\frac{11}{16}$	$\frac{11}{16}$	2		$\frac{7}{8}$	$1\frac{1}{2}$	
American Cotton											
Draw Frame . . .	$1\frac{1}{4}$	$1\frac{1}{8}$	$1\frac{1}{4}$	$1\frac{1}{4}$	1	1	1	1	$1\frac{1}{4}$	$1\frac{3}{16}$	$1\frac{1}{2}$
Slubber . . .	$1\frac{1}{8}$	1	$1\frac{1}{8}$		1	1	1		$1\frac{1}{4}$	$1\frac{1}{2}$	
Intermediate . .	$1\frac{1}{8}$	1	$1\frac{1}{8}$		$\frac{15}{16}$	$\frac{15}{16}$	$\frac{15}{16}$		$1\frac{3}{16}$	$1\frac{1}{2}$	
Rover . . .	$1\frac{1}{8}$	$\frac{7}{8}$	$1\frac{1}{8}$		$\frac{7}{8}$	$\frac{7}{8}$	$\frac{7}{8}$		$1\frac{3}{16}$	$1\frac{7}{16}$	
Mule-double boss . .	1	$\frac{3}{4}$	1		$\frac{3}{4}$	$\frac{3}{4}$	$\frac{3}{4}$		$1\frac{1}{4}$	$1\frac{11}{16}$	
Throstle . . .	1	$\frac{1}{2}$	1		$\frac{3}{4}$	$\frac{3}{4}$	$\frac{3}{4}$		$1\frac{1}{4}$	$1\frac{9}{16}$	
Egyptian Cotton											
Draw Frame . . .	$1\frac{1}{2}$	$1\frac{1}{4}$	$1\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{1}{4}$	$1\frac{1}{4}$	$1\frac{1}{4}$	$1\frac{1}{4}$	$1\frac{3}{8}$	$1\frac{11}{16}$	$1\frac{3}{4}$
Slubber. Iron flats .	$1\frac{3}{16}$	$1\frac{1}{4}$	$1\frac{3}{16}$		$1\frac{1}{4}$	$1\frac{1}{4}$	$1\frac{1}{4}$		$1\frac{1}{2}$	$1\frac{9}{16}$	
,, Round clearers	$1\frac{3}{16}$	$1\frac{1}{4}$	$1\frac{3}{16}$		$1\frac{1}{4}$	$1\frac{1}{4}$	$2\frac{1}{2}$				
Intermediate. Iron flats	$1\frac{3}{16}$	$1\frac{1}{4}$	$1\frac{3}{16}$		$1\frac{3}{16}$	$1\frac{1}{4}$	$1\frac{3}{16}$		$1\frac{1}{2}$	$1\frac{5}{16}$	
,, Round clearers	$1\frac{3}{16}$	$1\frac{1}{4}$	$1\frac{3}{16}$		$1\frac{3}{16}$	$1\frac{3}{16}$	$2\frac{1}{4}$				
Rover. Iron flats . .	$1\frac{1}{8}$	$1\frac{3}{16}$	$1\frac{1}{8}$		$1\frac{1}{8}$	$1\frac{3}{16}$	$1\frac{1}{8}$		$1\frac{7}{16}$	$1\frac{9}{16}$	
,, Round clearers	$1\frac{1}{8}$	$1\frac{3}{16}$	$1\frac{1}{8}$		$1\frac{1}{8}$	$1\frac{3}{16}$	$2\frac{1}{4}$				
Jack. Iron flats . .	$1\frac{1}{8}$	$1\frac{3}{16}$	$1\frac{1}{8}$		$1\frac{1}{8}$	$1\frac{3}{16}$	$1\frac{1}{8}$		$1\frac{5}{8}$	$1\frac{1}{2}$	
,, Round clearers .	$1\frac{1}{8}$	$1\frac{3}{16}$	$1\frac{1}{8}$		$1\frac{1}{8}$	$1\frac{3}{16}$	$2\frac{1}{4}$				
Mule. Single boss .	$1\frac{1}{16}$	$\frac{7}{8}$	$1\frac{1}{16}$		$1\frac{1}{8}$	$\frac{7}{8}$	2		$1\frac{1}{4}$	$1\frac{5}{8}$	
,, Double boss .	$1\frac{1}{16}$	$\frac{7}{8}$	$1\frac{1}{16}$		$\frac{7}{8}$	$\frac{7}{8}$	$\frac{7}{8}$				
Throstle . . .	$1\frac{3}{16}$	$\frac{7}{8}$	$1\frac{1}{16}$		1	$\frac{3}{4}$	2		$1\frac{1}{4}$	$1\frac{5}{16}$	
Sea Islands Cotton											
Draw Frame . .	$1\frac{1}{2}$	$1\frac{1}{4}$	$1\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{1}{4}$	$1\frac{1}{4}$	$1\frac{1}{4}$	$1\frac{1}{4}$	$1\frac{3}{4}$	$1\frac{7}{16}$	2
Slubber. Iron flats .	$1\frac{3}{16}$	$1\frac{1}{4}$	$1\frac{3}{16}$		$1\frac{3}{16}$	$1\frac{1}{4}$	$1\frac{3}{16}$		$1\frac{11}{16}$	$1\frac{7}{16}$	
,, Round clearers	$1\frac{3}{16}$	$1\frac{1}{4}$	$1\frac{3}{16}$		$1\frac{1}{2}$	$1\frac{1}{4}$	$2\frac{1}{2}$				
Intermediate. Iron flats	$1\frac{3}{16}$	$1\frac{1}{4}$	$1\frac{3}{16}$		$1\frac{1}{8}$	$1\frac{3}{16}$	$1\frac{1}{8}$		$1\frac{11}{16}$	$1\frac{3}{4}$	
,, Round clearers	$1\frac{3}{16}$	$1\frac{1}{4}$	$1\frac{3}{16}$		$1\frac{3}{16}$	$1\frac{3}{16}$	$2\frac{1}{4}$				
Rover. Iron flats . .	$1\frac{1}{4}$	$1\frac{3}{16}$	$1\frac{1}{4}$		$1\frac{1}{8}$	$1\frac{3}{16}$	$1\frac{1}{8}$		$1\frac{5}{8}$	$1\frac{5}{8}$	
,, Round clearers .	$1\frac{1}{4}$	$1\frac{3}{16}$	$1\frac{1}{4}$		$1\frac{3}{16}$	$1\frac{3}{16}$	$2\frac{1}{4}$				
Jack. Iron flats . .	$1\frac{1}{4}$	$1\frac{3}{16}$	$1\frac{1}{4}$		$1\frac{1}{8}$	$1\frac{3}{16}$	$1\frac{1}{8}$		1	$1\frac{3}{4}$	
,, Round clearers .	$1\frac{1}{4}$	$1\frac{3}{16}$	$1\frac{1}{4}$		$1\frac{3}{16}$	$1\frac{3}{16}$	$2\frac{1}{4}$				
Mule. Single boss . .	$1\frac{3}{8}$	$\frac{7}{8}$	$1\frac{9}{16}$		$1\frac{1}{4}$	$\frac{7}{8}$	2				

the distances apart being greater. It is also evident that short cotton fibres will require closer setting, and, to allow this, the diameter of the rollers must be proportionately small.

With regard to the thickness of the material being drawn, the quantity of twist, and the amount of draft, each of these affects the setting more or less. A thick roving requires more open setting of the rollers, a fine one closer setting. An extra quantity of twist in the roving also requires the distances of the

rollers to be greater, whilst slack twisted roving should have
closer setting. The draft affects the setting on account of the
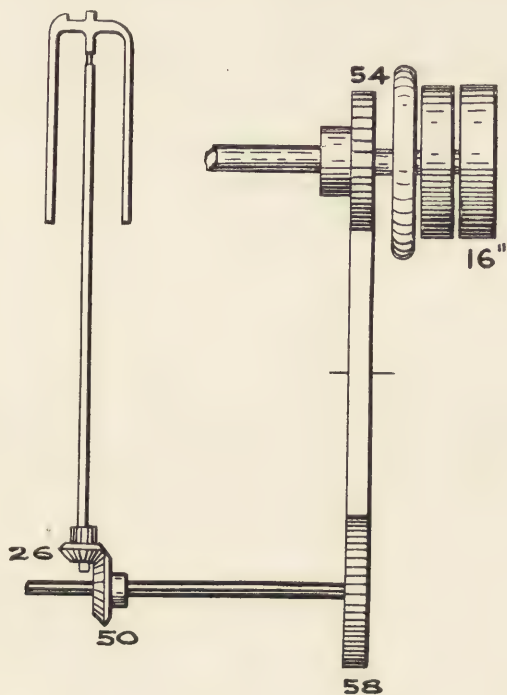difference in speed between the successive lines of rollers, and it

Fig. 104.—Elevation showing Connection between Frame Shaft
and Spindle.

becomes necessary to adopt closer setting when a very large draft
is introduced, or more open setting for a very small draft.

The table of diameters and distances of rollers will be found
of practical use (*see* p. 202).

Calculations—Slubbing Frame.

(1) *Required to find speed of the spindle.*

Suppose line shaft is running at 250 revolutions per minute.

Suppose drum is 18″.

Suppose pulley on frame is 16″ (*see* fig 104).

Then speed of frame shaft is $\dfrac{250 \times 18}{16} = 281\cdot25$.

Speed of spindle is $\dfrac{54}{58} \times \dfrac{50}{26} \times 281\cdot25 = 503$ revolutions of spindle.

(2) *To find the draught of slubber.*

First take the sizes of the rollers (*see* fig. 105).
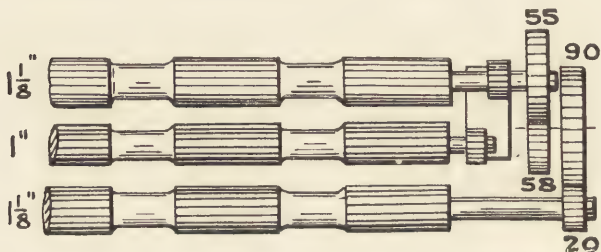
FIG. 105.—PLAN OF ROLLERS OF FLY FRAME.

Front roller $= 1\frac{1}{8}''$.

Middle roller $= 1''$.

Back roller $= 1\frac{1}{8}''$.

(*a*) Front roller wheel $=$ 20 teeth.

(*b*) Crown roller wheel $=$ 90 teeth.

(*c*) Draft or change wheel $=$ 58 teeth.

(*d*) Back roller wheel $=$ 55 teeth.

Note.—Exactly the same method of calculation obtains as in the case of the drawing frame.

Rule.—Multiply front roller wheel (*a*), change wheel (*c*), and diameter of back roller for divisor, and multiply crown wheel (*b*), back roller wheel, and diameter of front roller for a dividend.

(3) *To find what number of turns the spindle makes for one of front roller.*
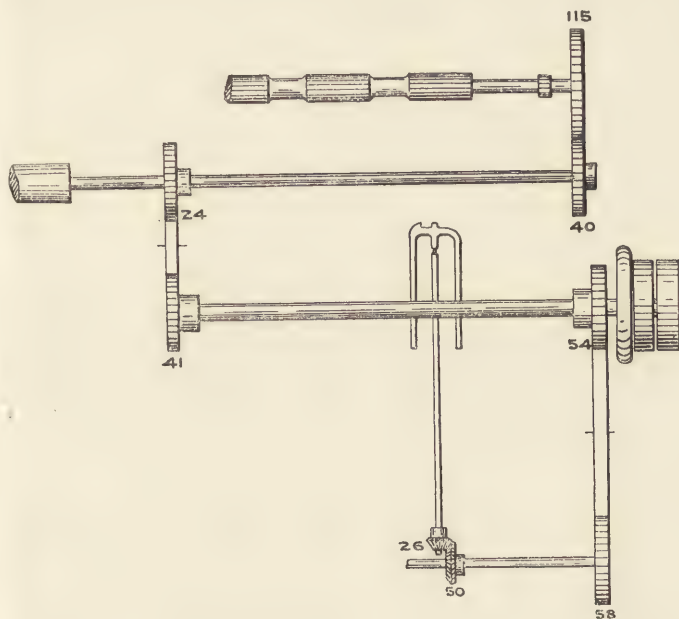
FIG. 106.—DIAGRAM SHOWING DRIVING FOR FRONT ROLLER OF FLY FRAME.

(*a*) Given driving wheel 54 teeth (*see* fig. 106).

(*b*) Given outside spindle shaft wheel 58 teeth.

(*c*) Given skew gear wheel 50 teeth.

(*d*) Given spindle wheel or wheel on the end of spindle 26 teeth.

(*e*) Given twist wheel 41 teeth.

(*f*) Given top cone drum inside wheel 24 teeth.

(*g*) Given top cone drum outside wheel 40 teeth.

(*h*) Given front roller wheel 115 teeth.

Rule.—Multiply the wheel on the end of the front roller, the inner cone drum wheel ; the spindle driving wheel behind the pulleys and skew gear wheel that drives the spindle, for the dividend ; and, for a divisor, multiply the outer cone drum wheel, twist wheel, the spindle shaft spur wheel, and the spindle bevel wheel.

(4) *To find the twist per inch on the frames.*

Rule.—Divide the turns of the spindles for front roller one by the circumference of the roller ; the quotient will be the turns per inch.

Let us suppose the turns of the spindle for one of the front roller be 10, and the diameter of the front roller to be $1\frac{1}{8}$."

While the front roller is completing one revolution, $3\cdot1416 \times 1\frac{1}{8}''$ of roving pass through, and in the same time the spindle makes 10 complete revolutions.

Therefore 10 complete twists are given, say, to the roving which has passed through front roller while completing one revolution. It is easy therefore to calculate how many twists per inch are given if we know 10 are given in the length named.

This is worked out thus : $\dfrac{10''}{1\frac{1}{8} \times 3\cdot1416}$ or $\dfrac{\frac{10}{1}}{\frac{9}{8} \times \frac{22}{7}} = \dfrac{280}{99}$
or 2·82 twists per inch.

(5) *On the alteration of hank.*—For a less hank a larger pinion is required, and for a greater hank a smaller pinion is required.

Rule.—Hank being made, multiply number of teeth in the pinion divided by the required hank.

(6) *To find the twist wheel required when changing from one hank to another.*

Rule.—Find the square root of
$$\frac{\text{square of wheel on} \times \text{hank being made}}{\text{required hank}}$$

Example.—If a ·75 hank is being made with 39's twist wheel, find the twist wheel for a $1\frac{1}{4}$ hank.

$$= \sqrt{\frac{39 \times 39 \times \cdot 75}{1\cdot 25}} = \sqrt{912\cdot 6} = 30\cdot 2, \text{ say 30 twist wheel.}$$

(7) *To find the star wheel when changing from one hank to another.*
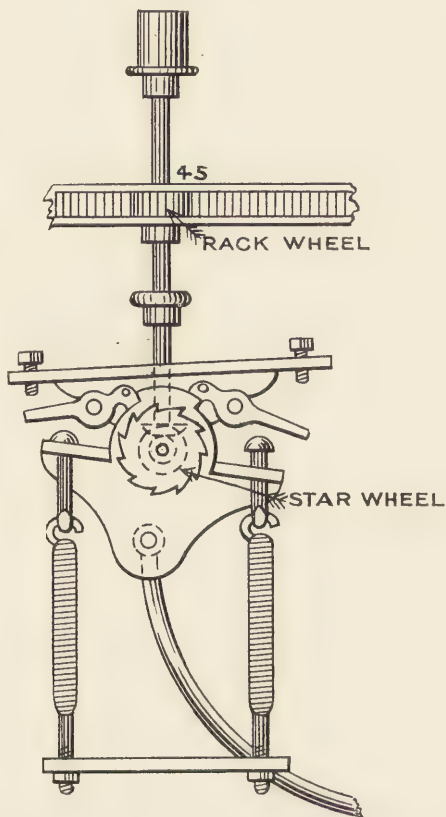
FIG. 107.—DIAGRAM SHOWING DETAILS OF STAR WHEEL AND RACK WHEEL OF FLY FRAME.

Rule.—(*See* Fig. 107.)

$$\sqrt{\frac{\text{The sq. of star on} \times \text{required hank}}{\text{hank being made}}} = \text{star wheel.}$$

Star wheel on = 22.   Hank required $1\frac{1}{4}$.
Hank being made ·857.

$$\sqrt{\frac{22 \times 22 \times 1\cdot25}{\cdot857}} = \sqrt{705\cdot9} = 26\cdot5 \text{ star wheel}$$

required, say 27.

This shows that the hank roving required being finer, a wheel with a greater number of teeth is required.

(8) *To find the strike or lifter wheel in changing from one hank to another.*

Rule.—

$$\sqrt{\frac{\text{sq. of strike wheel on} \times \text{hank being made}}{\text{hank required}}}$$
$$= \text{strike wheel required.}$$

Strike wheel = 20.
Hank being made = ·857.
Hank roving required = 1·25.

$$\frac{20 \times 20 \times \cdot857}{1\cdot25.} = \sqrt{274\cdot24} = 16\cdot5.$$

Say 17 strike wheel.

Indicators.—Indicators for registering the number of hanks per spindle delivered by the front roller, and thereby enabling the wages of the tenters to be readily calculated, have long been in almost universal use on bobbin and fly frames. They are of varying construction, and the two following sets of particulars enable both their construction and the method of calculation to be comprehended.

(9) The front roller of a roving frame is $1\frac{1}{4}''$ diameter, and the hank indicator upon it has the following train : The

worm A on the front roller drives a wheel B having 45 teeth, and on its axis is a pinion of 6 teeth driving a wheel C of 60 teeth, and on its axis is a pinion of 5 teeth driving a wheel D of 60 teeth, and on its axis is a pinion of 5 teeth driving a wheel E of 60 teeth, and on its axis is a pinion of 5 teeth driving a wheel F of 60 teeth, and this carries the clock or indicator finger.

How many hanks will the front roller deliver whilst the clock finger goes once round? (L. and C. Union of Institutes Exam. 1896.)

Answer—Circumference of roller equals $\dfrac{5}{4} \times \dfrac{22}{7}$ in inches.

Front roller makes $\dfrac{45 \times 60 \times 60 \times 60 \times 60}{1 \times 6 \times 5 \times 5 \times 5}$ revolutions. Then

$\dfrac{5}{4} \times \dfrac{22}{7} \times \dfrac{45 \times 60 \times 60 \times 60 \times 60}{1 \times 6 \times 5 \times 5 \times 5}$ divided by $12 \times 3 \times 840$ will give the hanks put off.

$$\therefore \frac{5 \times 22 \times 45 \times 60 \times 60 \times 60 \times 60}{4 \times 7 \times 1 \times 6 \times 5 \times 5 \times 5 \times 12 \times 3 \times 840} = 101 \cdot 02 \text{ hks.}$$

It is usual to allow $1\frac{1}{4}$ % for breakage, and if this answer be reduced by that amount, we get—

$$100 : 98 \cdot 75 :: 101 \cdot 02 = 99 \cdot 75 \text{ hanks net.}$$

(10) On a roving frame the diameter of the front roller is $1\frac{1}{8}''$. A single worm on front roller drives an 85-worm wheel. On same stud is a second worm driving a 100 wheel. On same stud as the last wheel is a third worm driving another 100. On same axis as the last wheel is the indicator finger. Prove whether these wheels are so correct as to register 100 hanks when exactly that length has passed through the front roller to each spindle.

$$\frac{100 \times 100 \times 85 \times 9 \times 22}{12 \times 3 \times 840 \times 8 \times 7} = 99 \cdot 38 \text{ hanks.}$$

Only 99·38 hanks have passed through the front roller to each spindle, whilst 100 hanks have been registered, which is therefore ·62 hank in favour of the tenter. If $1\frac{1}{4}\%$ be allowed for breakage, this gives some advantage to the tenter, unless allowed for in the price.

If one of the 100 wheels were changed to a 101, the result would be 100·37, and if the other 100 also were changed to 101, we should be about the mark for allowing the $1\frac{1}{4}\%$, say 100·37 hanks delivered whilst 100 hanks per spindle were registered.

Note.—A good way to comprehend the theory of the above calculations is this :—Regard the last wheel of the series, upon which is fastened the indicator finger, as the driver, and its speed as 1. By the rule for speeds find the revolutions of front roller to one of indicator finger.

Then multiply result by circumference of front roller and divide by 36×840 to find inches delivered.

The practical use of indicators is shown by the following calculation :—In taking the indicators on a pair of roving frames at crossing-off time, suppose one shows at 98, and the previous week it was at 64. The other shows at $24\frac{1}{2}$, and the previous week it was taken at 90. The tenter is paid $3\frac{1}{4}d$. per hank ; find her week's wage.

1st frame has done $\quad 98 - 64 = 34 \quad$ hanks per spindle.

2nd ,,   ,,   ,, $124\cdot5 - 90 = 34\cdot5$,,   ,,

$$\text{Total hanks} = 68\cdot5.$$

$$\frac{68\cdot5 \times 3\cdot25}{12} = 18\cdot5 \text{ shillings, say } 18s. \; 6d.$$

Below is given an example typical of what is necessary when making a change of counts at the bobbin and fly frames.

A 9-hank roving is being made with a 45 change pinion, a

40 twist wheel, a 36 ratchet wheel, and an 18 small strike wheel. Find wheels necessary for 12-hank roving.

$$\frac{45 \times 9}{12} = 33\cdot75 \text{ change pinion wheel.}$$

$$\frac{40 \times \sqrt{9}}{\sqrt{12}} = \frac{40 \times 3}{3\cdot46} = 34\cdot68 \text{ twist wheel.}$$

$$\frac{18 \times \sqrt{9}}{\sqrt{12}} = \frac{18 \times 3}{3\cdot46} = 15\cdot60 \text{ strike wheel.}$$

$$\frac{\sqrt{12} \times 36}{\sqrt{9}} = \frac{3\cdot46 \times 36}{3} = 41\cdot52 \text{ ratchet wheel.}$$

It will be noticed that we have obtained the square roots of the counts ; and this method is decidedly preferable to squaring the wheels on, when the same square roots come in for more than one calculation, as in above example.

(11) *Production.*—A slubbing frame front roller is $1\frac{1}{4}''$ diameter, and makes 150 revolutions per minute. It contains 80 spindles and is making a 1-hank slubbing. Find production in $56\frac{1}{2}$ hours, allowing $4\frac{1}{2}$ hours for stoppages.

$$\frac{5 \times 22 \times 150 \times 60 \times 52 \times 80}{4 \times 7 \times 12 \times 3 \times 840 \times 1} = 4,863 \text{ lbs.}$$

(12) *To find the twist.*—The best practical method to find the twist on these frames is simply to count the revolutions of spindle to one of front roller, and then perform a simple division calculation as follows :—

Revolutions of spindle to one of front roller, 10. Diameter of front roller, $1\frac{1}{4}$. Find turns per inch.

$$\frac{10 \times 4 \times 7}{5 \times 22} = 2\cdot54 \text{ turns per inch.}$$

(13) *To find the drag.*—It is highly important that we should know how the rate of winding is proportioned to the delivery of roving by the rollers, and the following method may be adopted :—

Revolutions of main shaft of frame per minute　　.　350
Number of teeth in twist wheel　.　　.　　.　　.　35
　　,,　　,,　,,　　,, wheel on centre of top cone shaft　.　40
　　,,　　,,　,,　　,,　　,, ,, end　,,　,,　　,,　　,,　.　40
　　,,　　,,　,,　　,,　　,,　　,, ,,　.　,,　　front roller　.　120
Diameter of front roller in eighths of an inch　.　　.　$\frac{9}{8}$ths.

$$\frac{350 \times 35 \times 40 \times 9 \times 22}{40 \times 120 \times 8 \times 7} = 360\cdot93''$$

= inches delivered per spindle, per minute, by front roller.

Revolutions of sun wheel per minute　.　　.　　.　　.　18
Number of teeth in the driving part of compound or bell

　　wheel　.　　.　　.　　.　　.　　.　　.　　.　　.　50
Number of teeth in wheel on end of bobbin shaft　.　　.　40
　　,,　　,,　　,,　,, in bevels on bobbin shaft　.　　.　50
　　,,　　,,　　,,　,, small bobbin bevels　.　　.　　.　25
Diameter of empty bobbin in eighths of an inch　.　$\frac{10}{8}$ths.

$$\text{Then } \frac{18 \times 2 \times 50 \times 50 \times 10 \times 22}{40 \times 25 \times 8 \times 7} = 353\cdot57$$

= inches wound on per minute.

$360\cdot93 - 353\cdot57 = 7\cdot36''$ less wound on than are delivered by front roller. This means either that the ends are somewhat slack or the $7\cdot36''$ are taken up by twist.

Note.—The revolutions of front roller would be found usually more readily by actual counting than by calculation.

With respect also to finding the tension, a practical man would usually find it best to adopt the following method :—See that the cone belt is level with the ends of the drums immediately after doffing, and by actual examination ascertain whether the ends are of the proper tension during the first traverse of the lifter rail. If the ends are too slack or too tight, the number of teeth in the wheel that drives the sun wheel may be increased or diminished as may be required. If both

lifter speed and rate of winding are wrong, then the bottom cone end wheel might be altered in size.

Sun and Planet Motion.—The following calculations are intended to demonstrate the method of making calculations, depending more or less upon Holdsworth's differential winding motion, a description of which is given elsewhere in this treatise.

(14) In a flyer leading frame, the diameter of empty bobbin is 1·5″, and the diameter of full bobbin is 3·75.″ The front roller delivers 400″ per minute per spindle. Find the number of revolutions per minute which the bobbin must lose on the spindle to wind the material on, both for full and empty bobbins.

$$\frac{400 \times 7}{22 \times 3·75} = 33·9 \text{ revolutions loss for full bobbins.}$$

$$\frac{400 \times 7 \times 2}{22 \times 3} = 84·8 \text{ revolutions loss for empty bobbins.}$$

(15) In a bobbin leading slubbing frame the compound bobbin wheel gains 15 revolutions per minute upon speed of main shaft when winding upon full bobbins; how many revolutions per minute will the sun wheel move?

$$15 \div 2 = 7·5 \text{ revolutions of sun wheel.}$$

(16) Revolutions of roving frame main shaft, 350 per minute. Twist wheel, 30. Wheel on centre of top cone shaft, 40. Take the diameter of top cone at 5·5″ and diameter of bottom cone drum at 5″. Wheel on end of bottom cone 20, driving a plate wheel 120 teeth. On same stud as plate wheel is a 25 bevel wheel driving sun wheel 125 teeth. Find revolutions per minute of sun wheel, allowing 10 per cent. for slipping of cone belt.

$$\frac{350 \times 30 \times 5·5 \times 20 \times 25 \times 90}{40 \times 5 \times 120 \times 125 \times 100} = 8·66 \text{ revolutions of sun wheel.}$$

Racks.—There are three kinds of racks about a bobbin and flyer frame, and the following will indicate the method of making calculations in connection with them.

(17) *Lifter racks*.—Let it be granted that the lifter in an intermediate frame moves at the rate of 10″ per minute. The lifter pinions which gear into these upright racks have each 16 teeth $\frac{3}{8}$″ pitch.

Find revolutions of lifter shaft per minute.

$$16 \times \tfrac{3}{8} = 6''.$$
$$\tfrac{10}{6} = 1\cdot 6 \text{ revolution.}$$

(18) The pitch of the round rack for regulating length of lift is $\frac{1}{4}$″, and the rack travels 8″ during the making of a set of bobbins. Find revolutions of the round rack wheel when it contains 20 teeth.

The rack wheel will be 5″ round—

$$\frac{20 \times 1}{4} = 5''.$$

Then, $\dfrac{32}{4 \times 5} = 1\cdot 6$ revolution per minute.

(19) The rack for moving cone belt has a total traverse of 26″, and is $\frac{3}{8}$″ pitch. The wheel that drives it contains 30 teeth ; find its revolutions.

$$\frac{26 \times 8}{30 \times 3} = 2\cdot 31 \text{ revolutions.}$$

Standard Twists. — Strictly speaking, there are no standard turns per inch for bobbin and fly frames, as in the case of mules. There are, however, recognised rules, which form a basis for the guidance of managers, &c.

For American cotton it is good practice to take as a standard 1·2. For Egyptian, say 1·05, and for Sea Islands, say ·85.

In each case the standard number or coefficient is multiplied into the square root of the counts.

(20) Find the turns per inch required for 4-hank roving American cotton.

$$\sqrt{4} \times 1.2 = 2.4 \text{ turns per inch.}$$

(21) Find turns per inch required for 9-hank roving Egyptian cotton.

$$\sqrt{9} \times 1.05 = 3.15 \text{ turns per inch.}$$

(22) Find turns per inch for 20-hank roving Sea Islands cotton.

$$\sqrt{20} \times .85 = 3.7995 \text{ turns per inch.}$$

CHAPTER XVI

Spinning. The Mule.—The process of spinning the rovings produced by the rover or jack frame into yarn includes the operations of drawing, twisting, and winding into the form of a cop or of a bobbin. When the spinning 'mule' is the method by which the first-named objects are accomplished a cop is formed, and when the spinning is done on the 'throstle' the spun yarn is wound on to a bobbin.

The mule, on account of its greater utility, is the principal spinning machine in use, and because of its many special motions is the most complicated of the whole range of cotton machinery. Its action is made entirely automatic, and hence it is usually called the self-acting mule, or 'self-actor.'

The self-acting mule has three lines of drawing rollers, which are supported on a stationary beam, called the roller beam, running the whole length of the machine. The spindles are contained in a carriage which runs backwards and forwards; they put the twist in the yarn as the carriage recedes from the roller beam, and wind the yarn on to the spindles as the carriage comes back.

The general arrangement of a pair of mules in a mill is shown in fig. 108. The headstocks A, from which all the motions are derived, are placed near the middle of the machines in the manner shown, so as to leave a passage the whole length and put the pair in the smallest space, to economise room. This plan of placing mules enables the 'bays' (*i.e.* distance from pillar to pillar) of a mill to be smaller than would other-

wise be possible. The roller beam B and creel C extend from one end to the other, their length being usually equal to the width of the mill, less passages. The travelling carriage D, which is supported by grooved bowls running on 'slips' S, also stretches the whole length. The two halves of the carriage are joined together through the headstock in a special manner, to ensure perfect rigidity. The extreme ends of the carriages are carried on the framings F. The mechanical movements of the mule which are brought into play in one draw or travel of the carriage are very numerous. As the mule commences to work (1) the drawing-out motion causes the drawing rollers to operate and reduce the rovings, and the carriage begins to travel outwards to
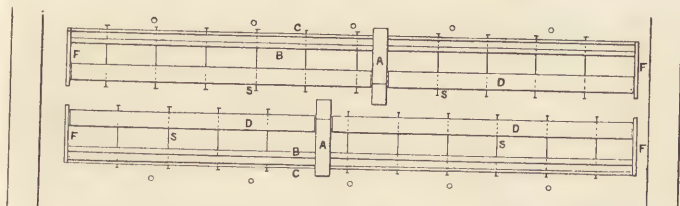
Fig. 100.—Plan of a Pair of Self-acting Spinning Mules.

a certain distance, called the 'stretch'; (2) the twisting motion allows a requisite number of turns of the spindles to be made, and then they are stopped; (3) after the rollers have ceased to deliver yarn, at this point a jacking motion, which continues the outward run of the carriage, so that the yarn may be made uniform, comes into play; and (4) a roller turning motion turns the rollers slightly to relieve this strain and give the yarn elasticity; (5) the backing-off motion reverses the spindles, so as to uncoil the yarn, that is in spirals, from them, and to allow the faller wire to guide the yarn upon the cops; (6) the drawing-up motion pulls the carriage in; and meanwhile (7) the shaper which forms the cops on the spindles commences to work; simultaneously (8) the winding motion begins to turn

the spindles, and continues to do so until the carriage gets in ;
(9) the 'roller motion' meanwhile acts, and causes the rollers
to deliver several inches of yarn, so as to wind on all the spun
yarn ; (10) a motion to tighten the backing-off chain auto-
matically, so as to enable it to act on the fallers as early as
possible ; (11) the 'governor motion,' the object of which is to
regulate the winding during the formation of the cops.
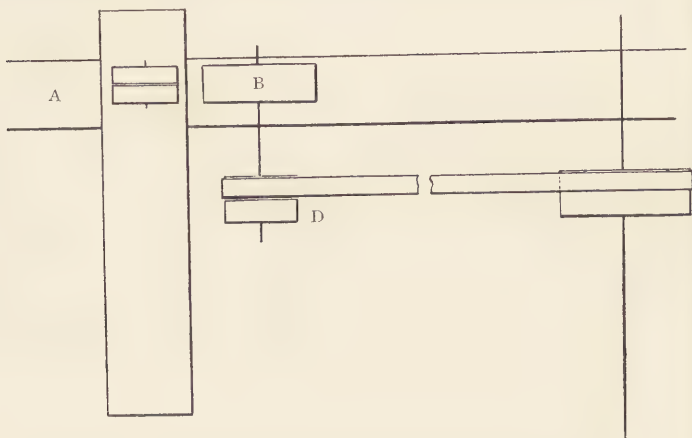
Fig. 109.—Plan showing Single Speed Driving of Mule.

The above are all the important motions of the machine ;
but some of them, viz. the jacking motion, the roller-turning
motion, and the roller motion, are not generally used except for
fine spinning. The usual method of driving a mule is shown
in fig. 109. It will be seen that the pulleys A on the rim
shaft of the headstock are driven from a drum B on the counter-
shaft. This counter-shaft receives motion from the main shaft
of the room by another belt, as shown, and has both fast and
loose pulleys, so that it can be stopped at will. The outside
pulley D is the fast one, through which the whole weight of the

driving is transmitted, and it is therefore placed nearest to the hanger by which the end of the shaft is supported. The speed of the counter-shaft is constant. As the whole machine is driven by the rim shaft, the speed of the latter is of great import-ance, and varies according to the material being spun by the mule.

Another arrangement of mule driving is shown in fig. 110. This is called double-speed driving, and is used when spinning fine numbers only. The reason for its use is the following : On account of the delicate character of very fine yarn as com-
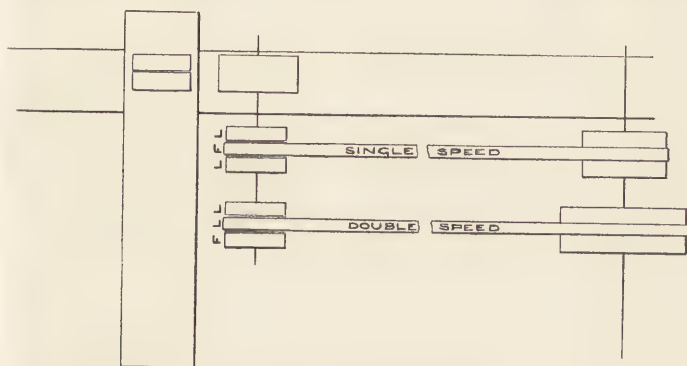
FIG. 110.—PLAN SHOWING SINGLE AND DOUBLE SPEED DRIVING.

pared with coarse, the spinning of the former has to be performed very carefully, and therefore the carriage is made to come out much slower ; the spindles are likewise retarded, and every other motion connected with the actual spinning—that is, drawing and twisting—is done at a correspondingly slower speed.

On account of this, a mule spinning 250's would require about three times as long to perform one draw as another mule spinning 60's if both were driven in the manner shown in fig. 109. Double-speed driving is an arrangement for saving time, because

it is only necessary for the spinning to be done slowly, and
there is no reason why the backing-off and subsequent motions
of the draw should not be accomplished quickly, as on any
other mule. This is done, as shown in fig. 110, by driving the
counter-shaft at two different speeds during the two portions of
a draw.

The letters on the pulleys in fig. 110 distinguish the fast
and loose pulleys, each set of which consists of three. During
the run-out of the carriage the straps are on the middle pulleys
of the sets, as indicated. The counter is therefore being driven
by the single speed, as one strap is on the fast pulley of that
set. When the rollers cease to revolve, however, a motion on
the headstock causes the setting-on rod to move the straps in
the direction of the arrow, and the other strap now becomes
the driver, and on account of the different size of the line-shaft
drum the counter is driven at the increased speed. This counter
continues acting until the carriage gets in, when the reverse
motion takes place and single speed acts again. The double
speed comes into play as soon as the spinning process is com-
pleted, that is, when the rollers stop. This may be some inches
before the carriage gets out, according to the amount of 'ratch'
or jacking introduced. Although the carriage is moving very
slowly at this time, the speed of the spindles is increased by two
or three thousand revolutions per minute, while the ad-
ditional twist is being put in. When the mule is to be stopped
the strap forks are both moved in the other direction, and each
belt comes upon a loose pulley (*see* fig. 110) and the counter-
shaft is at rest. The manner in which the moving of the belt
is accomplished will now be seen on a reference to fig. 111,
which is an elevation of the headstock and counter-shaft of a
mule fitted with double-speed driving. The double-speed set
A has its fast pulley next to the hanger, whilst the single-speed
set B has its fast pulley in the middle.

During the time the carriage is running out the upright rod R is gradually raised up by means of an eccentric C, which acts on the lever D. This lever, as shown by the dotted lines, is
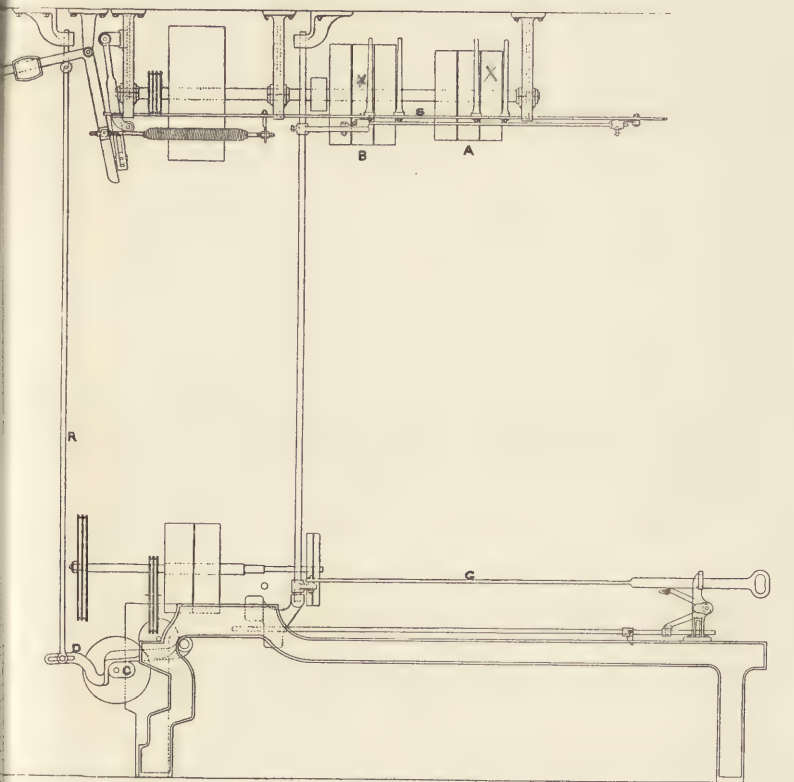
FIG. 111.—ELEVATION OF HEADSTOCK, SHOWING ARRANGEMENT FOR SINGLE AND DOUBLE SPEEDS.

centred on the back shaft, and the cam is driven by wheels. The rod R has a washer on it which moves the weighted arm of a lever suspended from the ceiling. The other arm of this lever is connected with a spring, the extreme end of which is held

by the sliding strap-guide s. As this weight is raised its pressure is removed from the strap guide, and the latter is then pulled only by the spring, which, however, does not move it until the carriage, reaching a certain point in its traverse (when the rollers cease revolving), unlatches the setting-on rod G, and it is carried forward, where it is again latched and held until the carriage gets in again. Then the setting-on handle is again unlatched, and the rod R coming down allows the weighted lever to fall, and this falling weight pulls the straps over again to the single speed.

The principles and construction of mules by all makers are very identical, differing only in the methods of making the necessary self-acting changes, and, of course, in their adaptation to certain classes of work. The method of spinning fine counts varies somewhat from that of coarse counts.

Fine counts of yarn contain more twist and are capable of a greater draft, by reason of the long staples from which they are spun. But, owing to the thinness of the material, it is less able to withstand the strain of twisting. The practice is, therefore, to put as little twist as possible into the yarn during the run out of the carriage, and to introduce the full twist when the carriage is out, this being known as 'twisting at the head.' The rollers cease to revolve and cease to deliver yarn before the carriage arrives at the end of the stretch, and as the carriage continues to run out the yarn reaching from the spindles to the rollers is stretched, making an additional draft. During this short period, which is called 'jacking,' the thick places are drawn out, whilst the thin, which are not stretched, on account of the greater twist they contain—through the twist having naturally run into the thin places during spinning—are unaffected, and the yarn is thus made very uniform. Of course twisting has the effect of contracting yarn, and a considerable tension results. This is relieved during jacking

SPINNING

LONG LEVER MOTION FOR MULE
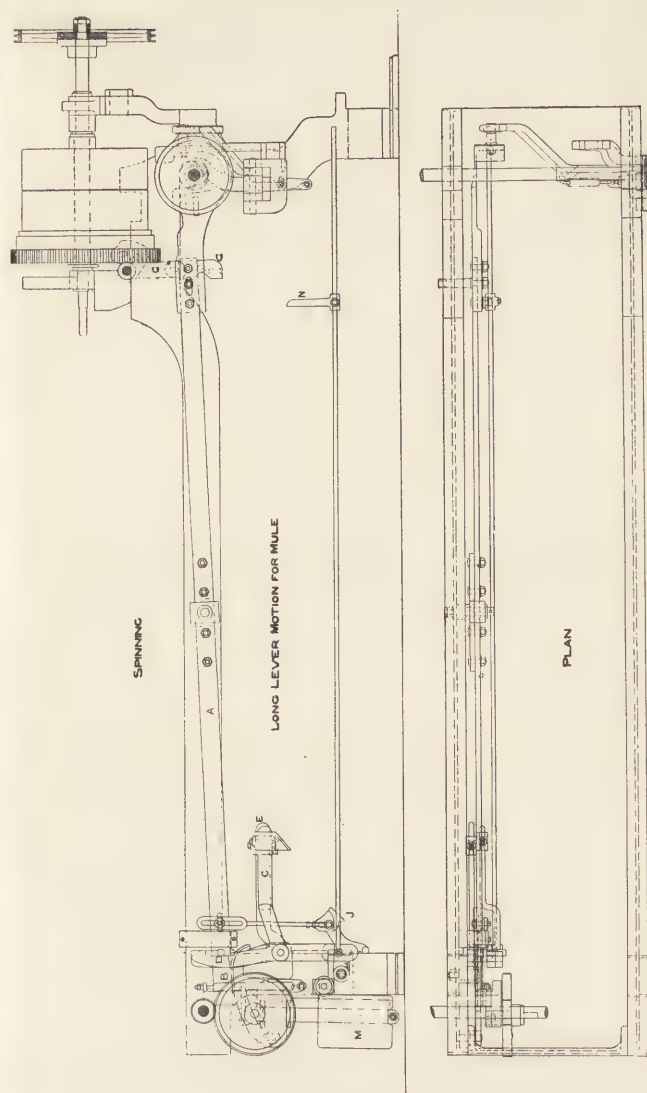
PLAN

FIG. 112.—ELEVATION AND PLAN OF THE POSITION OF THE LONG LEVER WHEN SPINNING.

by means of the roller delivery motion, which causes the rollers to turn and deliver half or three-quarters of an inch of roving. This easing was formerly accomplished by causing the carriage to recede a little towards the rollers, but the surer motion is now always employed.

The particular type of mule chosen for description here is that known as the long-lever mule, so called because the changes are performed by the action of a long lever instead of by a series of cams placed on a cam shaft. It is equally suitable for spinning all counts, but is, perhaps, best known as a fine spinning machine.

Figs. 112 and 113 show the general arrangement of the working parts of the headstock during the periods of spinning, backing off, and winding on, and the relative positions of the long lever A.

This lever is carried by a stud fixed about midway of the headstock side, its parts being formed to act on other levers and cause the changes to occur.

Referring now to fig. 112, showing the position of the lever during spinning, that is, the outward travel of the carriage, it will be seen that the out end B of the lever is in its lowest place. There is a square stud on its side, which, being engaged with a shoulder D on the upright arm of another lever C, controls it in that position. When the carriage gets out, a triangular stud carried by it comes into contact with the small incline J, which lifts up and allows the stud to pass, upon which the incline falls again and the carriage is locked, thus preventing a return until twisting and backing off are completed. At about the same moment that this takes place another contrivance on the carriage comes against the incline of the lever C, which is caused to lift up, this movement, of course, putting the vertical arm out of contact with the long lever. As the latter is counter-weighted at the other end, it swings, but the

square stud in going upwards is caught by the shoulder of a
second elbow lever E and stopped. The long lever has now
assumed the position shown in the upper drawing in fig. 113, that
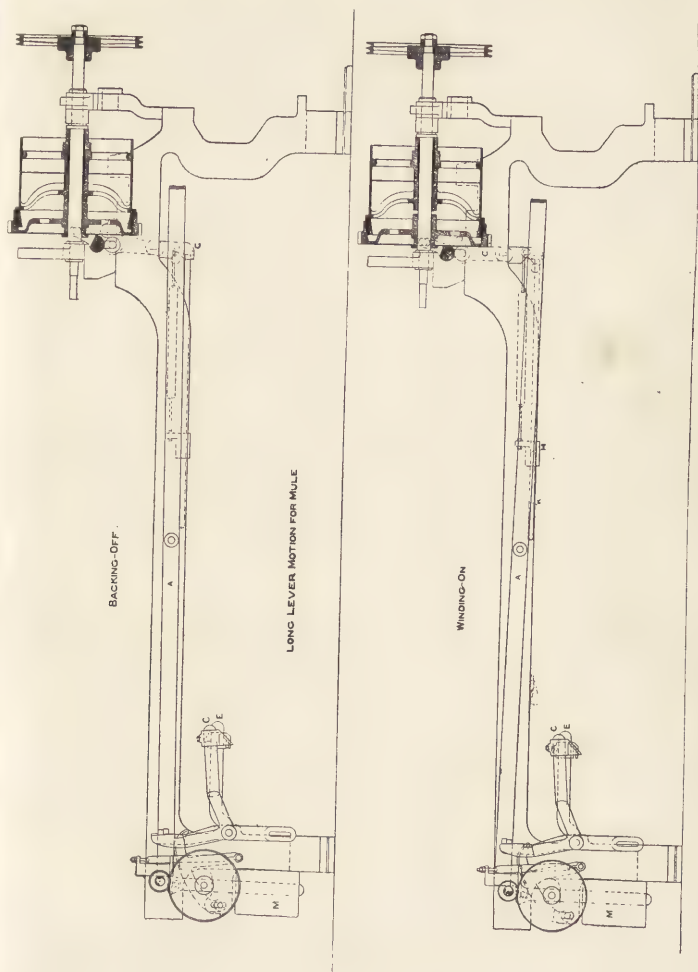
FIG. 113.—ELEVATION SHOWING THE POSITION OF THE LONG LEVER, BACKING-OFF, AND WINDING-ON MOTION.

is, it is horizontal.   The movement of the out end of the lever has
caused a corresponding downward movement of the other end
(near the pulleys), the effect of which is seen in comparing the
two drawings.   A pin in the long lever, which during the run
out of the carriage was resting against a flat part of the friction
controlling arm G, has been thrown opposite the recess shown.
At first this has no effect, because the ' twisting at the head '
has not taken place, but immediately that process is completed
the lower part of G is rapidly pulled outwards, thus throwing
the upper part (which carries a fork engaged in the groove of
the friction wheel) towards the pulleys and gearing the
friction surfaces.   This movement is brought about as follows :—
The lever G (*see* fig. 113) is connected by a spring, shown in
dotted lines, to a fast washer H fixed on a long rod K, also
shown dotted.   The spring is held in tension during spinning,
and consequently on being actuated by the rod K violently
pulls the lever, and backing off commences.   The spring is put
into tension by means of a ' gun lever,' as it is called, and
which is carried by the carriage framing.   This comes into
contact with a part of the rod K and carries it outwards, thus
tightening the spring.   At the proper moment for backing off
to commence the spring is released, and the clutch lever sent
forward as described.   As previously mentioned, backing off
is the operation of stopping and reversing the spindles, so as to
uncoil the yarn wound in spirals on the upper part of the
blade preparatory to winding.   It is obvious that the direction
of the rim shaft must be reversed in order to reverse the
spindles.   The sketch (fig. 114) will enable the action to be
better understood.   The fast pulley has connected with it a
leather-covered surface called the friction cone, which is made
to engage with another internal leather friction cone.   The
latter has its circumference B formed into a spur wheel, and is
driven, through a side shaft C, from the drawing-up pulley A.

As this pulley is worked from the counter-shaft it is evident that the rim shaft and the side shaft C parallel to it both revolve in the same direction, and consequently the backing-off friction B revolves in the contrary direction. When the belt gear is actuated the strap is pushed on to the loose pulley and becomes practically powerless; the backing-off friction is violently engaged, as already described, and reverses the rim. The spindles are almost instantly stopped, and made to revolve
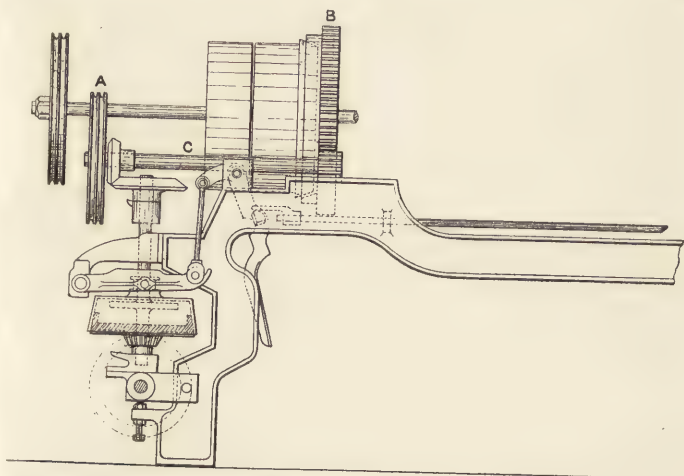
Fig. 114.—Elevation showing the Backing-off and Drawing-up Frictions in the Mule Headstock.

in the other direction for a few seconds, so as to uncoil the yarn on the spindle blade; at the same time the faller wire is depressed, while the counter-faller rises to take up the slack yarn, and the winding commences.

The belt is not moved back on to the fast pulley until the carriage gets back to the roller beam, although during winding the spindles revolve in their normal direction, being controlled by the winding motion. Having now seen what is the

object of backing off, it will be necessary to follow the changing of the long lever to the completion of the draw. When the locking of the faller takes place (by which is meant the placing of the faller under the control of the shaper) a lever connected with the faller locking motion raises the second elbow lever E, and the long lever is again released, and swings upward under the influence of the counter-weight at the other end. The long lever has now taken the position shown in fig. 113 marked ' winding.' In its upward movement it carries with it the connecting rod attached to J, and releases the carriage.

The winding on of the yarn now commences, the carriage being pulled in by means of bands on the drawing-up scrolls. The scroll shaft is driven by means of a pair of bevels from an upright shaft, which in turn is driven from the overhead counter-shaft (*see* fig. 114). The vertical shaft carries a friction cone, which at the proper time descends on to its corresponding cone and sets the scroll shaft in motion. The upper cone is pressed downwards by a lever controlled by a powerful spring, which, however, is kept from descending by means of a finger upon the long lever. This finger is so fixed that during spinning and backing off the cone is held up ; but simultaneously with the long lever making its change into the winding position the finger releases the lever and the spring forces the gearing of the cones to take place, and the run in of the carriage then follows. Just before the carriage reaches the stops a part of it comes against the finger N on the long rod shown, and carries it inwards ; this pulls the lower part of the piece controlling the long lever and leaves the latter free to come down to its first place, which it quickly does under the influence of a heavy drop weight M (*see* fig. 113).

The Quadrant.—The object of the quadrant is to regulate the winding of the thread by diminishing the speed of the spindles during winding, in proportion as the diameter of the

cop increases. This is rendered necessary on account of the time for taking in of carriage being uniform throughout the set, and the amount of yarn to be wound on being also uniform. As the size of the cops increases, an increasing amount of yarn would be taken up in each succeeding revolution of the spindles if the latter preserved a constant speed. The velocity of the spindles must therefore be slowered as the cop is built, in order to avoid breaking the thread. This reduction of speed will of course be greatest at the beginning of the set, and when the full thickness of the cop is once attained a state of permanency begins, which, with the exception of a small allowance for the taper of the spindle, will act until the nose of the cop commences to form, when the lessening diameter necessitates a speeding up. The quadrant operates as shown in fig. 115. It turns on a fixed centre A, and its toothed edge—representing the quadrant of a circle—is driven by a pinion B actuated through a band and grooved pulley receiving motion from the traverse of the carriage. The arm of the quadrant is grooved and contains a screw with sliding nut A^1. The nut is traversed along the screw by means of a quadrant governing motion, to be described later, and it is evident that by thus altering the position of the nut the length of the chain attached to it will represent a greater or smaller distance from A^1 to the winding-on drum.

At the commencement of the cops the nut A^1 is in its lowest position close to A, so that the point at which the chain is linked to A^1 describes a very small arc round the centre A. If we suppose this movement to be nothing, or, in other words, that A^1 remains stationary, a length of chain equal to the traverse of the carriage—say 64″—is wound on the drum A^2, which is 6″ diameter. If we now suppose the nut to be in the highest position it can attain, the point A^1 will be almost vertically over the pinion B when at the end of the outward stretch, while at
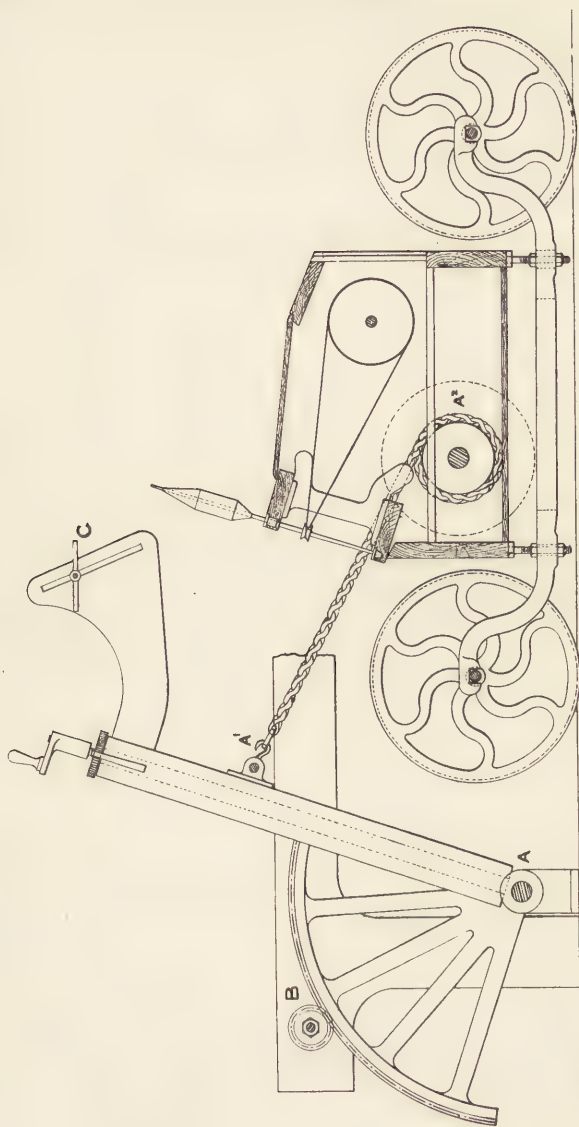
FIG. 115.—ELEVATION OF THE QUADRANT, AND SECTION OF THE CARRIAGE OF THE MULE.

the end of the run in of the carriage the quadrant has turned so much to the right that the length of chain from A^1 to the winding drum is almost horizontal. It is plain that the effective length of chain now causing the revolution of the drum is $64''$, minus the horizontal projection of the arc described by A^1, and gradually moving the slide nut from the lowest to the highest position : this length to be deducted is gradually increased, and thereby the rotary motion of the spindles is reduced in speed. Shortly after the cop has attained its full diameter the opposite conditions exist, and the spindle must be accelerated during the terminal portion of the winding period, so as to meet the effect of the decreasing diameter of the spindle. The contrivances that accomplish this are called 'nosing motions.' The very simplest form of nosing motion is the one called the 'nose-peg,' which is shown in fig. 117. At each inward run of the carriage the nose-peg c comes in contact with the winding chain and deflects it, thus pulling the winding drum round and accelerating the spindles. The nose-peg is arranged to impart the extra speed to the spindles just before the carriage gets in, and thus it compensates for the taper of the spindle blade. The nose-peg requires much attention, as the deflection of the winding chain should be slightly greater each succeeding draw, and the difficulty of working it properly, so as not to cause hatched and loose cop noses, constitutes its principal drawback.

On the other hand, the automatic nosing motion is so worked as to regulate the building of the nose with great firmness. A good example of nosing motion is Dobson and Hardman's patent, the chief feature of which is the perfect relation existing between the motion and the copping faller. This motion is illustrated in figs. 116 and 117. The faller rod supports a tappet to which is hung a lever A with an arm B, moving with the copping faller (*see* fig. 116). The movement of the carriage consequently works the motion by means of the finger B, as will be seen.

A bracket D (*see* fig. 117) which is placed near the quadrant centre has a segmental toothed rack formed on it, into which rack two catches engage. These catches are carried in a lever E,
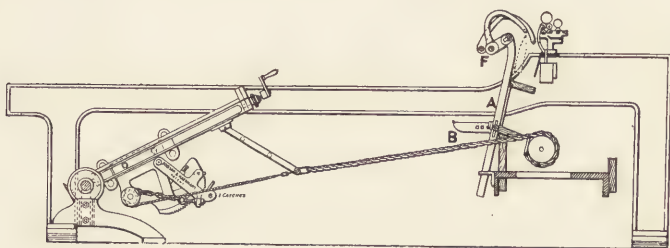
FIG. 116.—NOSING MOTION IN ELEVATION.
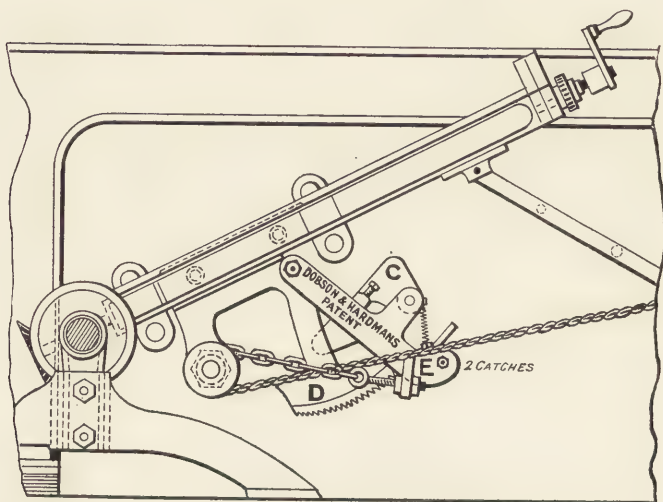
FIG. 117.—DETAILS OF THE NOSING MOTION.

pivoted from the upper part of D. The lever E has a chain attached to an ear at its lower end, which passes round a small pulley, as shown, and is connected to the winding chain. There is also a pin in E, carrying a compound tumbler C, the latter being

in two pieces, each at liberty to move freely when acted upon. The tumbler has a projection cast upon it which rests on the lever E. When a set of cops is commenced the lever E is at the bottom of the quadrant, and the winding-on chain, which in the figure is replaced by a chain and link, describes a straight line. Each time the carriage comes out the finger B (*see* fig. 116) comes against the lower part of the tumbler C (*see* fig. 117), which lifts up and allows it to pass. As the carriage begins to run in the finger presses the projection on the tumbler against E, and by so doing raises it. The distance through which this tumbler is raised depends on the length of time the pressure is maintained. The raising of the lever pulls the chain, and consequently gives a downward pull to the joint of the link and chain. This draws them out of line, which is equivalent to shortening the winding chain. The object of accelerating the spindles is thus attained.

Now if A does not alter its position from one stretch to the next, the lever E also remains stationary, and as the position of A depends entirely on that of the faller, the lever E is sure to occupy the corresponding position, which is an advantageous arrangement, seeing that, if the faller rises slowly, as when spinning fine counts, the position of E alters slowly, and *vice versa*. The minder has no control over the motion, because if he by any means alters the position of E to relieve the tension on his yarn, the next draw will rectify it, and tight winding is ensured throughout. The winding-on chain may be attached either to the quadrant arm in the ordinary way or to a hanging link, as shown.

The driving of the drawing rollers is obtained from the rim shaft in the manner shown in fig. 118, which is an illustration of the roller and jacking motions in plan. A pinion on the rim shaft drives through a carrier the small side shaft A, which has a bevel pinion B gearing with another C, on the front roller. The latter has formed on it one half of a clutch box, the other

half being so arranged as to slide out of gear. When the carriage is coming out the rollers are being driven by the side shaft at the desired speed for delivering the yarn, but immediately the long lever changes the clutch box is thrown out of gear and this driving of the rollers ceases. The jacking then comes into action
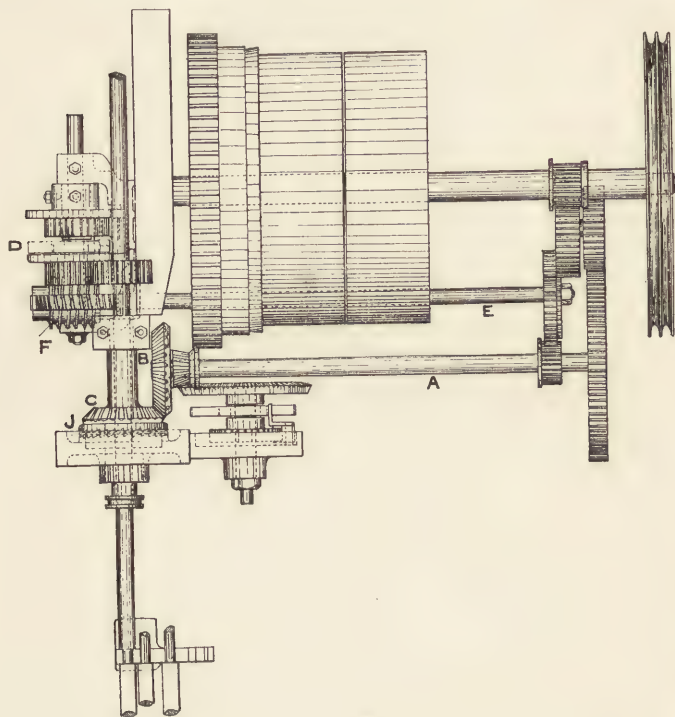
Fig. 118.—Plan showing Roller and Jacking Motions of the Mule.

to relieve the tension while twisting. Driven by the same gearing as the shaft A is another side shaft E, which carries at its outer end a worm F. This gives motion to another train of gearing, and drives the rollers very slowly through a clicking clutch D, the

teeth of which are so formed as to be inoperative whilst driven
in one direction, the click slipping over the teeth without
effect. This is the case whilst the rollers are being driven
through the side shaft A, but as soon as the rollers are stopped
the clutch J becomes a driver and turns the roller slowly, thus
introducing the jacking.

The sketch shows that as long as the rim is being turned
in its forward direction, motion is imparted to the front roller
by one or other of the two side shafts.

The shaping or building of a cop, so as to produce firm-
ness, and thus prevent waste during handling and unwinding,
is a very important part of the work of a mule, and, indeed,
is also the principal point of a spinner's or minder's training.
The process of building the set of cops on the spindles cannot
be fairly understood without some knowledge of the action of
the fallers. Of these there are two, known respectively as the
copping faller and the counter-faller. The shafts are placed side
by side, and form part of the carriage, as shown at A and B in
fig. 119. They run exactly parallel to the roller beam, the
copping faller being nearest to the spindles and strongest in
construction. They carry a number of sickles, which are made
to carry the 'faller wires.' The object of the copping faller is
to guide the yarn on to the spindles at the proper place, and it
is therefore requisite that it should be controlled in a rigid
manner. During the outward run of the carriage this wire
is above the spindle points, while that of the counter-faller is
below. The duty of the latter, as explained before, is to take
up the extra length of yarn caused by backing off, and to keep
the whole of the ends tight during winding. The counter-
faller, therefore, is not controlled rigidly, but rather so as to
yield when pressure is put upon the tension of the threads
from any cause. The illustration (fig. 119) shows a curved
sector carried by the counter-faller, and a chain, attached at

one end to the sector and at the other to a weighted lever L hinged on to the under side of the carriage. This weight is enough to oscillate the counter-faller when allowed to do so, but the weight is sustained by a wire fastened to the lever nearer the fulcrum. This wire is hooked to a bracket D fixed on the copping faller shaft; D is made with an arm or stop
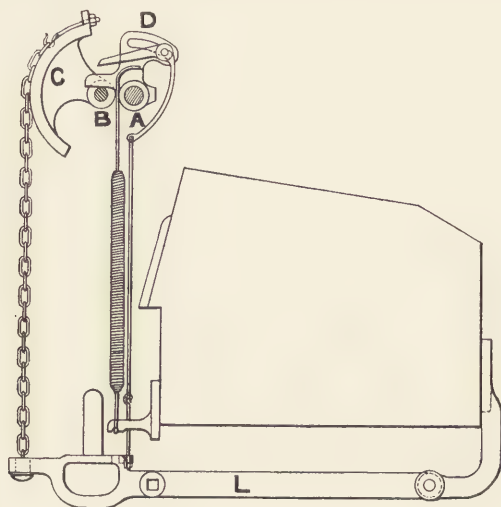
IG. 119.—ELEVATION SHOWING THE FALLER MOTION OF THE MULE.

A. Copping shaft; B. Shaft; C. Sector; D. Bracket on copping faller shaft;
L. Weighted lever.

resting on the counter faller shaft, and is constantly pulled downwards on to it by the spring shown. When backing off the copping wire descends, and consequently allows the vertical wire to slacken and throw the weight on to the sector C. This pulls the chain and raises the counter-faller, and the wire lifts up the ends and holds them tight. The careful regulation of

the balance weights is the means of preventing this tightening from becoming excessive. When the carriage gets in the weight is raised by contact with a roller. The copping faller carries an arm N (fig. 120) curved so as to reach over the counter-faller, and joint to the locking lever L. A chain is fastened to the curved bracket, and passing round a pulley, borne by a lever, is connected to a snail on the tin roller shaft T. The snail does not move during spinning, but immediately the tin roller is reversed for backing off its ratchet comes into use, and as the tin roller runs backward the snail winds on the chain G and draws down the backing-off finger, which depresses the winding faller, whilst raising the locking lever L. As the copping faller reaches its lowest point to commence winding, the hollow H of the lever L is pulled over a finger F fixed at the end of a slide borne by the carriage. There is a bowl which rests on a long rail P, called the copping rail, and this bowl travels with the carriage. When the shoulder of the locking lever or 'boot leg' engages with the finger F, it is said to be locked, and also the copping faller is locked and winding can commence. It is obvious that the time of locking the faller will take place according to the position of the small bowl, and the regulation of this is the object of the copping or shaper rail. This latter is so made up of inclined surfaces as to control the shape of the cops, but the position of the rail is also varied to attain these results. During the building of the cops, the starting point of the winding is gradually raised, and the length of the traverse is varied. The traverse or vertical height of the actual winding is called the 'chase' of the cop. As the bowl which regulates the action of the locking lever rests on the top of the copping rail, it follows that its vertical movement is communicated to the winding faller, and the latter governing the counter-faller, the whole combination must work in harmony. The conditions to be fulfilled by the shaper are
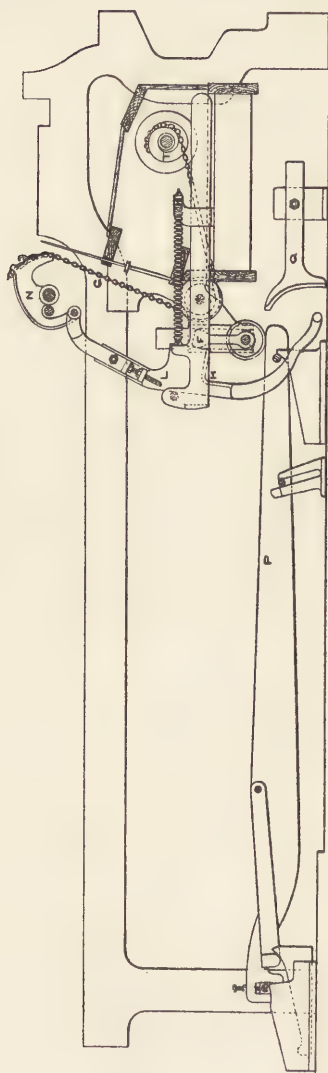
FIG. 120.—ELEVATION SHOWING LOCKING MOTION FOR FALLERS IN THE MULE.

F. Finger on slide; G. Chain; H. Lever hollow; L. Locking lever; N. Arm; P. Copping rail; Q. Curved stop; T. Snail on tin roller shaft.

such as to make the winding faller move vertically in one
direction, and the counter-faller vertically in the other at the
same time. The faller is unlocked by the tail end of the lock-
ing lever L coming into contact with a curved stop Q, the
shape of which varies the moment of unlocking. Another
important motion about all mules is one for automatically
regulating the traverse of the quadrant nut up the screw.
These are called governing motions, and are of various forms,
some acting during the outward run of the carriage and some
during the inward. In any case, they are controlled by the
height of the counter-faller during the inward run.

The lower this position is the more the quadrant nut is
traversed. In those motions which move the nut during the
run-out of the carriage, the extent of the movement is governed
by the position of the counter-faller at the time the carriage
gets in against the stops.

Calculations on the Mule.—(1) *To find the speed of the
counter-shaft, rim shaft, and spindles from the following par-
ticulars :*

Line shaft makes 220 revolutions per minute. (*See*
fig. 121.)

A=drum on the line shaft, and is 18″ diameter.

B=pulley on the counter-shaft, and is 15″ diameter.

C=drum on the counter-shaft, and is 24″ diameter.

D=pulley on rim shaft, and is 15″ diameter.

E=rim, and is 19″ diameter.

F=tin roller pulley, and is 11″ diameter.

G=tin roller, and is 6″ diameter.

H=spindle wharve, and is $\frac{3}{4}$″ diameter.

Speed of counter-shaft$=\dfrac{220 \times 18}{15} = 264$ revolutions.

Speed of rim shaft $= \dfrac{264 \times 24}{15} = 422$ revolutions.

$$\text{Speed of spindle} = 422 \times \frac{19}{11} \times \frac{6}{.75}$$

$$= 5,831 = \text{single speed of spindle.}$$
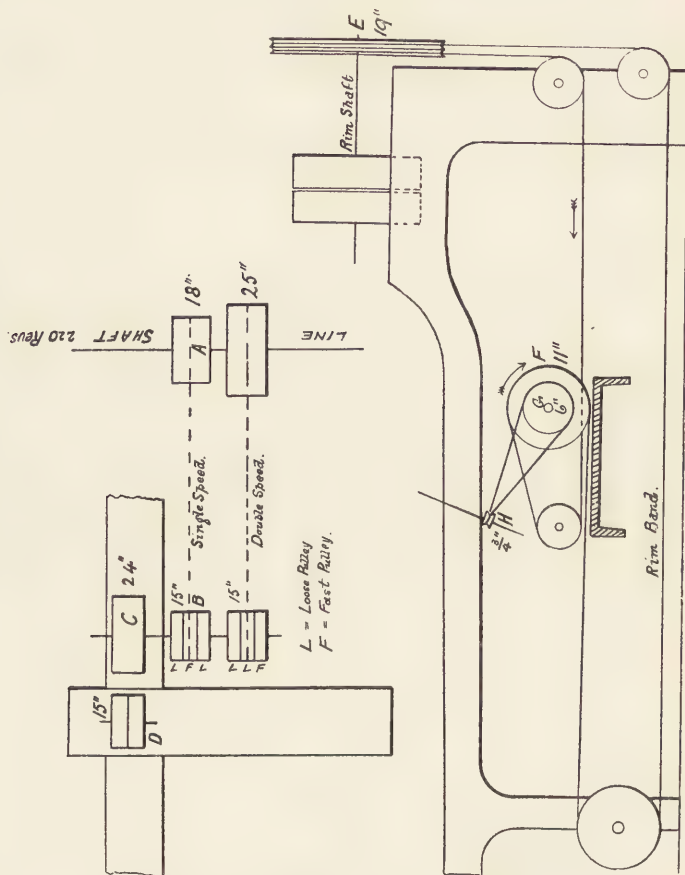
Fig. 121.—Plan showing Arrangement for Double and Single Speeds, and Elevation showing the Position of the Rim Band for Driving the Spindles.

If it is required to find the double speed of spindle, proceed as before, substituting for $\dfrac{18}{15}$ in above the calculation for the speed of the counter-shaft $\dfrac{25}{15}$.

This works out as follows :— $\dfrac{220}{1} \times \dfrac{25}{15} \times \dfrac{24}{15} \times \dfrac{19}{11} \times \dfrac{6}{\cdot 75}$

$= 8,106 =$ double speed of spindle.

(2) *To find the draft in the mule.*

Rule.—Top carrier wheel × back roller wheel × stretch, including roller motion, for dividend.

Change pinion wheel × front roller wheel × length delivered from the rollers for divisor (*see* fig. 122).
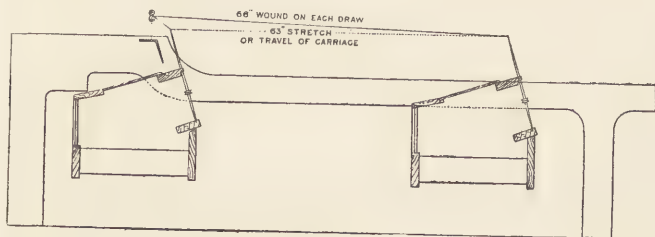
Fig. 122.—Elevation of Mule Carriage : Length of Stretch and Length Wound on Spindle.

Top carrier = 120 teeth.
Back roller wheel = 50 teeth.
Full length of stretch, including roller motion = 66″.
Change pinion wheel = 41 teeth.
Front roller wheel = 16 teeth.
Length delivered from roller = 60″.

$$\frac{120 \times 50 \times 66}{41 \times 16 \times 60''} = \frac{25 \times 33}{82} = \frac{825}{82} = 10\cdot06.$$

$10\cdot06 =$ draft of the mule.

(3) *To find what change pinion is required when commencing a new mule. The draft required must always be stated.*

Let it be supposed that a draft of 12 is required. All that is needed in this case is to substitute 12 in the place of the change pinion wheel in the calculation given above. This will work out as follows :—

$$\frac{120 \times 50 \times 66}{12 \times 16 \times 60} = \frac{275}{8} = 34\cdot3.$$

Say 34 change wheel required.

(4) *To find what pinion wheel is required when changing from one counts to another.*

This is really a matter of simple proportion. Suppose we say we are spinning 32's with a 40 change pinion, and we are required to spin 46's.

32's counts are spun with a 40's wheel.

1's ,, ,, ,, ,, $\dfrac{40 \times 32}{46}$.
46's ,, ,, ,, ,,

$$= \frac{40 \times 32}{46} = 27\cdot8, \text{ say } 28, \text{ change pinion wheel.}$$

The rule is to multiply the change pinion wheel which is by the counts being spun and divide by the counts required.

(5) *To find the pinion when the counts and the hank roving in the creel are to be altered.*

$$\frac{\text{Counts spinning} \times \text{pinion} \times \text{hank roving to put in creel}}{\text{Counts to be spun} \times \text{hank roving in creel}}$$

Example.—If the mule is spinning 60's with 12-hank roving in creel and 36 pinion on, and it is required to spin 40's with a 10-hank roving. Find the pinion required.

Then $\dfrac{60 \times 36 \times 12 \times 10}{40 \times 12} = 45$ pinion wheel required.

(6) *To find the twist wheel when new mules are to be started.*

Rule.—Turns per 1″ × stretch, including roller motion, and divide by revolutions of the spindle for one of rim.

Let it be supposed we have 28 turns per inch, 66″ stretch, including roller motion, 11·74 revolutions of spindle to one of the rim—

$$\frac{28 \times 66}{11 \cdot 74} = 157 \cdot 4.$$

As the twist wheel goes round twice while the twist is being put in the yarn, this 157·4 must be divided by 2—

$$\frac{157 \cdot 4}{2} = 78 \cdot 7.$$

(7) *To find twist wheel when changing from one counts to another.*

Rule.—

$$\sqrt{\frac{\text{Twist wheel}^2 \times \text{counts to be spun}}{\text{Count spinning}}}.$$

Suppose the twist wheel is 84 and counts being spun = 70's. We are required to spin 40's.

$$\text{Then } \sqrt{\frac{84 \times \overset{12}{\cancel{84}} \times 40}{\cancel{70}}} = \sqrt{1008 \times 4}$$

$$= 4032 \, (63\cdot4 \text{ twist wheel.}$$
$$\begin{array}{r} 36 \\ \hline 123 \quad 432 \\ 369 \\ \hline 1264 \quad \cdot6300 \end{array}$$

(8) *To find the draft that will be required in the rollers when there is a gain or draft in the carriage.*

Example.—What draft will be required to spin 40's from a 5¼-hank roving, the rollers to deliver 60,″ and length of stretch 63″?

R 2

Rule.—

$$\frac{\text{Hank roving} \times \text{length of stretch}}{\text{Counts} \times \text{length delivered}}.$$

$$\therefore \frac{40}{5\frac{1}{4}} \times \frac{60}{63} = \frac{\frac{40}{1}}{\frac{21}{4}} \times \frac{60}{63}$$

$$= \frac{160}{21} \times \frac{60}{63} = \frac{9600}{1323} \Big) 9600 \Big(7\cdot25 \text{ draft required.}$$
$$\underline{9261}$$
$$\cdot 3390$$

(9) *To find what the rollers deliver.*

This calculation is very similar to the last.

Rule.—

$$\frac{\text{Hank roving} \times \text{draft between rollers} \times \text{length of stretch}}{\text{Counts spinning}}.$$

$$\frac{5\frac{1}{4} \times 7\cdot25 \times 63}{40} = \frac{\frac{21}{4} \times \frac{29}{4} \times \frac{63}{1}}{\frac{40}{1}}$$

$$= \frac{21 \times 29 \times 63}{640} = 59\cdot9, \text{ say 60 inches delivered.}$$

It sometimes happens that in changing from one counts to another a suitable pinion wheel is wanting. When this is not available, the same result may be obtained by a change in the back roller wheel.

Example.—A 49's pinion, say, is required, and the back roller wheel is 54 ; what back roller will produce the same draft with a 40's pinion?

Rule.—

$$\frac{\text{Back roller wheel on} \times \text{pinion to be put on}}{\text{Pinion required}}.$$

$$\frac{54 \times 40}{49} = \frac{2160}{49} = 44 \text{ back roller wheel required.}$$

(10) *To find what change wheel is required when a change of back and front wheels is made.*

Example.—

Counts spinning, 40's.　　Change pinion, 40.
Front roller wheel, 16.　　Back roller wheel, 42.
Crown wheel, 108.

We want a front roller wheel of 18 and a back roller wheel of 50. Find the change pinion to spin the same counts.

Rule.—

$$\frac{\text{F roller wheel} \times \text{c. pinion} \times \text{bk. roller wheel required}}{\text{F. roller wheel required} \times \text{bk. roller wheel on}} \cdot$$

$$\frac{\overset{8}{\cancel{16}} \times \overset{20}{\cancel{40}} \times 50}{\underset{9}{\cancel{18}} \times \underset{21}{\cancel{42}}} = \frac{8000}{189}$$

189) 8000 (42·3 change wheel required.
　　 756
　　 ———
　　 440
　　 378
　　 ———
　　 ·620

(11) *To find a change wheel that will produce any required counts from a given hank roving.*

Rule.—

$$\frac{\text{Crown wheel} \times \text{bk. r. wheel} \times \text{hank roving} \times \text{dia. of f. roller}}{\text{F. roller wheel} \times \text{counts required} \times \text{dia. of bk roller}} \cdot$$

Front roller wheel = 20.
Counts required = 40's.
Crown wheel = 120.
Back roller wheel = 54.
Diameter of back roller = $\frac{7}{8}''$

Diameter of front rollers $= 1''$

Hank roving $= 5.$

$$\frac{120 \times 54 \times 5 \times 1}{20 \times 40 \times \tfrac{7}{8}} = \frac{3 \times \dfrac{27}{1} \times \dfrac{1}{1}}{2 \times \dfrac{7}{8}} = \frac{\dfrac{81}{1}}{\dfrac{7}{4}}$$

$$= \frac{324}{7} = 46 \cdot 3 \text{ change wheel required.}$$

Indicators.—Indicators for registering the amount of yarn spun by the mule have become of almost universal application. Unlike the indicators for fly frames, they cannot be put to work satisfactorily upon the front roller, as 'gain' and 'ratch' would interfere greatly with the accuracy of the registering. Formerly it was the custom to place them upon the cam shaft, but the excessive amount of vibration at every change of the cam caused it soon to get out of order. They were also somewhat liable to be tampered with. The mules now at work with indicators on the cam shaft are so few that it is not deemed worth while to give a calculation bearing upon them. Indeed, there are many mules that are worked absolutely on the lever rod and spring system, without the introduction of a cam shaft. The indicators mostly in favour at the present time are Orme's, and the following calculations explain their use when made to register hanks, the indicators being invariably placed on the back shaft :—

(12) On a pair of mules the indicators register up to 20,000 hanks. No. 1 indicator is taken at 19,000 at crossing-off time, and was taken at 18,000 the previous week. No. 2 indicator is taken at 4,000, and was taken at 2,500 the previous week.

How many hanks have the pair of mules turned off, and

what wages would be on the minder's ticket if the price were 14*d.* per thousand ?

Answer.—The first indicator registers 21,000 hanks, and the second indicator registers 21,500 hanks, and the total hanks are, therefore, 42,500.

$$
\begin{array}{r}
42500 \\
14 \\
\hline
170000 \\
42500 \\
\end{array}
$$
12) 595*d.*
20) 49*s.* 7*d.*
£2. 9*s.* 7*d.*—wages.

(13) *To prove an indicator.*—In a mule indicator the wheels on are 7, 15, and 30. The number of spindles in the mule is 1,028, and the length of stretch 64″. The indicator registers every three draws. Prove whether it be true or not ; and if there be any discrepancy, say whether it be for or against the minder.

$$\frac{7 \times 15 \times 30 \times 64 \times 1028 \times 3}{12 \times 3 \times 840} = 20{,}560 \text{ hanks.}$$

The indicator ought to register 20,000 hanks, whilst 20,000 hanks, plus 2½ %, are being turned through the rollers—

$$100 : 20{,}000 :: 2\tfrac{1}{2} : 500.$$

Calculated on the 20,560, the 2½ % would come to slightly more, but in either case the calculation works out so that there is no practical discrepancy, and what little there is counts against the minder, say 2*d.* per week or so. Mr. 'Lister' contends that 4 % would be a more accurate allowance for breakage, on account of the yarn winding slacker in the wrap reel than on the mule. We think 2½ % is quite enough, as it equals 50 ends always down on a pair of mules containing 1,000 spindles each, and no workman could keep up

with this. There is, however, a loss in cop bottom, waste, slack strings, bad noses to the cops, &c., which may make up the $2\frac{1}{2}$ % allowance.

Some indicators are made to register every $1\frac{1}{2}$ draw for large mules instead of every 3 draws, while others are in use for registering the number of 'draws' instead of the number of hanks.

Standard Turns per Inch in Yarn.—(*a*) For American cotton the standard twists are obtained by multiplying the square root of the counts by 3·75 for twist, and 3·25 for weft.

Example.—Find standard twists for 36's twist and 50's weft.

$$\sqrt{36} \times 3\cdot75 = 22\cdot50 \text{ twist.}$$
$$\sqrt{50} \times 3\cdot25 = 22\cdot98 \text{ weft.}$$

(*b*) For Egyptian cotton the standard turns per inch are obtained by multiplying the square root of the counts by 3·606 for twist, and 3·183 for weft.

Example.—Find standard twists for 66's twist and 90's weft.

$$\sqrt{66} \times 3\cdot606 = 29\cdot29 \text{ twist.}$$
$$\sqrt{90} \times 3\cdot183 = 30\cdot18 \text{ weft.}$$

(*c*) For Sea Islands cotton we might multiply the square root of the counts by $2\frac{3}{4}$.

Example.—Find turns per inch for 110's Sea Islands.

$$\sqrt{110} \times 2\cdot75 = 10\cdot488 \times 2\cdot75 = 28\cdot842.$$

(*d*) For hosiery yarns a comparatively small amount of twist per inch is required. A good rule is to multiply the square root of the counts by $2\frac{1}{2}$.

Example.—Find turns per inch for 40's hosiery yarn.

$$\sqrt{40} \times 2\cdot5 = 15\cdot80.$$

(*e*) For reeled yarn the standard is to multiply the square root of the counts by 3·394.

Example.—Find turns per inch for 54's reeled yarn.

$$\sqrt{54} \times 3\text{·}394 = 24\text{·}94.$$

'Gain' and 'Ratch.'—By 'gain' or 'drag' is meant the excess speed of the carriage over the surface speed of the front roller during any one stretch. In medium numbers twist there is often no 'gain.' In the same counts of weft there may be an inch or so. In hard twist and extra hard twist yarns there is always more yarn delivered than what is equal to the length of stretch, and the twist takes up the yarn. In some of these cases 70″ of yarn or so are delivered in a 64″ stretch. In low numbers of yarns the same effect is often produced in a less degree. In fine numbers there is invariably a fair amount of 'gain,' and also there is usually some degree of 'ratch.' By this latter term is meant that the rollers either cease to revolve altogether, or only revolve very slowly, whilst the carriage moves forward and pulls out the yarn, or 'ratches' it for a short distance, prior to the holding-out catch being reached.

This has a great tendency to pull out thick places in the yarn, and to make it uniform. For 100's or more we might have, say, 5″ 'gain' and 2″ 'ratch.'

Formerly the 'gain' wheels were made small, and a tooth change made too much alteration in the amount of 'gain.'

About 50 was often a common size for a drag wheel. Suppose 65″ were delivered in a 64″ stretch, and we changed the 51 drag wheel to a 50. What difference would it make in the gain?

$$\frac{65 \times 50}{51} = 63\text{·}7$$
$$65 - 63\text{·}7 = 1\text{·}3,$$

or more than $1\frac{1}{4}''$ of difference.

The gain wheels now used generally have upwards of 100 teeth. Suppose we changed this 100-teeth wheel to a 101, and

we previously delivered 65″ of yarn. Find difference in gain made by the one-tooth change.

$$\frac{65 \times 101}{100} = 65\text{·}65.$$

$$65\text{·}65 - 65 = \text{·}65,$$

or only a little more than half an inch, which could be done with impunity.

(14) *Practical methods of determining ' drag.'*

Rule.—First count the revolutions of the front roller per stretch. Multiply revolutions by circumference, which will give inches delivered per stretch. Compare this answer with length of stretch.

Example.—Stretch 60″. Diameter of front roller 1″, and its revolutions per stretch 18. Find gain.

$$3\text{·}1416 \times 18 = 56\text{·}5488″ \text{ delivered.}$$

$$\begin{array}{r} 60\text{·}0000 \\ 56\text{·}5488 \\ \hline 3\text{·}4512 \end{array} = \text{amount of gain.}$$

A second good rule is as follows :—

Take the product of the driving wheels between front roller and back shaft along with diameter of back shaft scroll, for a dividend. Take the product of driven wheels along with diameter of front roller, for a divisor. The quotient will show the amount of the carriage 'traverse,' or the 'gain,' for every inch delivered by the rollers. Several terms cancel out. The rule depends upon finding the revolutions of the back shaft to one of the front roller.

Example.—The front roller is 1″ in diameter, and the scroll 6·5″ in diameter. A 30 on the front roller drives a 90 drag wheel by means of a carrier. The small drag wheel contains 30 teeth, and drives a 60 back shaft wheel. Find the traverse or drag.

$$\frac{6 \cdot 5 \times 30 \times 30}{90 \times 60} = 1 \cdot 08 \tfrac{3}{} '' \text{ traverse,}$$

which means that every inch is pulled into $1 \cdot 08 \tfrac{3}{}$, or $1 \tfrac{1}{5}''$.

The amount of 'ratch' could be found by actual measurement, taking into account the small portion of yarn delivered during ratching.

Changing from Twist to Pincop Weft.—This may be best illustrated by giving a typical example.

(15) Suppose we are spinning 60's twist, and we desire to change to 80's pincop weft. The diameter of the twist cop is $1 \tfrac{1}{4}''$, and the diameter of the weft to be $\tfrac{7}{8}''$, these being the standard sizes. You change the hank roving from twofold 9 hank to twofold 12 hank. You have the following particulars for the 60's twist :—

Change pinion	40	teeth.
Builder wheel	40	,,
Twist wheel	65	,,
The diameter of the winding drum is $6''$.		
The gain wheel contains . .	100	teeth.

Find particulars for the 80's pincop weft.

$$\frac{60 \times 40}{80} = 30 \text{ change pinion required if the hank roving}$$

were unaltered, but as we have practically to change from $4\tfrac{1}{2}$ hank to 6 hank we shall require a larger pinion. How to get this is shown in the next operation.

$$(a) \qquad \frac{30 \times 6}{4 \cdot 5} = 40 = \text{ change pinion.}$$

There are several widely differing rules for working out the builder wheel. The following rule is based upon that given in Mr. Thornley's 'Self-actor Mules.'

Rule.—Multiply the diameter of the weft cop by the twist builder wheel, and by the square root of the weft counts, and

divide this product by the diameter of the twist cop and the square root of the twist counts :

$$(b) \qquad \frac{36 \times 7 \times 8 \times \sqrt{80}}{8 \times 10 \times \sqrt{60}} = 29 \text{ builder wheel.}$$

A tooth or two might be taken off this 29 builder wheel to allow for taking some weight from the fallers.

(*c*) Sometimes the winding for the weft is made right by simply starting the quadrant nut lower down, or by other means. A good method is to put on a smaller diameter of winding drum, according to the following rule :—Divide the product of the diameters of the weft cop and the twist winding drum by the diameter of the twist cop.

$$\frac{7 \times 6}{10} = 4 \cdot 2. \quad \text{Say } 4\tfrac{1}{4}'' \text{ diameter of winding drum.}$$

It must be distinctly understood that a change in diameter of winding drum is only useful because we are going to spin cops which are not only much less in diameter but are started much higher up the spindle. If the weft cops were spun as low down the spindles as the twist, there would be no necessity for altering the winding drum.

(*d*) Twist wheel.

Rule.—Find the standard turns per inch for both the twist and weft counts. Divide the product of the weft turns and the old twist wheel by the twist turns per inch.

As these are Bolton counts we will use Bolton standard :

$\sqrt{80} \times 3 \cdot 183 = 28 \cdot 45 =$ standard turns for the weft.

$\sqrt{60} \times 3 \cdot 606 = 27 \cdot 91 = \quad$ „ „ „ „ twist.

$\dfrac{28 \cdot 45 \times 65}{27 \cdot 91} = 66 \cdot 25$ twist wheel, say 66. This would

probably go twice round per stretch. As regards the variation in the 'gain' and 'ratch,' that would depend upon the judgment of the overlooker.

Probably the spindle bands would require to be reversed and various points in relation to the copping altered. The copping bowl should be raised, the fall in the rail diminished, and a less amount of the plates put to work.

The Quadrant Pinion.—It is not necessary to change this for a change of counts; in fact, this wheel sometimes works for years without being changed. Changing the size of the pinion may be expected to vary the 'winding' and the 'copping' somewhat.

A larger pinion will cause a less total amount of winding during any one run in of the carriage, and will tend to wind the cops somewhat softer. This effect is produced by the quadrant being driven more quickly forward, and it must be understood that the greater the retardation of the quadrant the keener the winding. A larger pinion has a tendency, however, to make firmer cop noses, and it is also often useful to put on a larger pinion when changing from pincop weft to bastards. It is unusual to apply calculations to the quadrant pinion, the custom being to put on a wheel having a tooth more or less according to the judgment of the overlooker, and to carefully note its effect on the winding and the copping.

CHAPTER XVII

Ring Spinning.—The ring frame, or ' throstle,' which is the name usually applied to the continuous spinning machine, is very widely used ; in fact, some cotton spinning-countries use no other machine for spinning, because it is suitable for the production of coarse and medium yarns. It is neither so complicated nor so useful as the mule, which is eminently suited to produce the coarsest and the finest yarns, but for spinning low numbers, say, up to 30's of strong quality, it is far more economical. The advantages of the throstle, in addition to the one of economy of working, are greater production, less floor space occupied, easier and more efficient lubrication, and, being much simpler in construction, it is less liable to breakdowns, and requires very little skill on the part of the attendants.

For the general run of English-made goods, these considerations are far more than outweighed by the advantages of the mule, which produces yarn of great uniformity and perfectness. It treats the material in a much more delicate manner than the ring frame, and hence it is the general machine used where Egyptian and fine cottons are spun, and is common for wefts of all numbers.

The illustration (fig. 123) will give a good idea of the ring frame. It has superseded the old flyer throstle because of its greater production. The flyer throstle has flyers in place of the more modern rings, and whereas in the flyer frame the flyer lays the yarn on the bobbins, in the ring frame the bobbin takes its yarn from a ' traveller '—a steel hoop, which is dragged

round the ring by the pull of the yarn on to the bobbin. This latter system is not theoretically so perfect as the other, but is much preferred for almost all counts of yarn. The spinning frame is arranged with three lines of drawing rollers, like the mule, but the draft of these is usually rather less than those of the mule, a finer hank roving being placed in the creel. ·
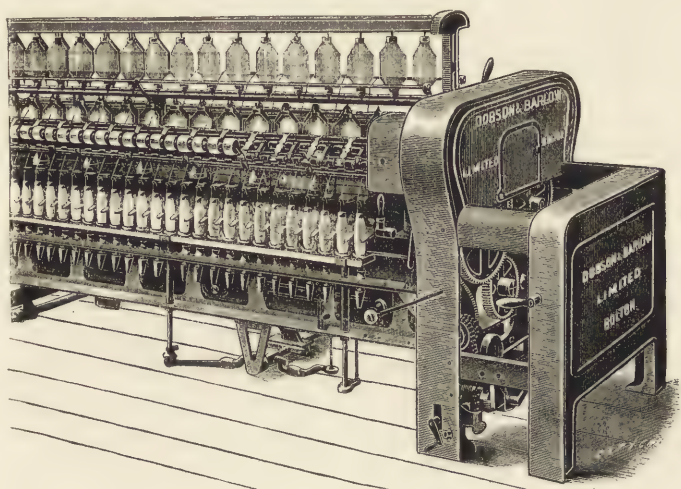
FIG. 123.—PART OF A RING SPINNING FRAME OR 'THROSTLE.'

Figs. 124 and 124*a* represent the gearing of the various parts. The driving pulley, driven by the line shaft belt, is keyed on one of the two tin roller shafts, the other being driven by wheels at exactly the same speed. The driving of the rollers on each side is also obtained by gearing, as shown, and almost the only motion which it is necessary to describe is the one which regulates the ascent and descent of the ring rail—in other words, the 'building motion.'

The preservation of the uniformity of the lift, so as to make a firm and well-shaped bobbin, is, however, a matter of great

importance, and depends on the shape and smoothness of a heart-shaped cam A. This cam is shown in fig. 124, and, it will be noticed, is situated near the floor. The driving shaft, by which, of course, is meant the tin roller shaft, or rather that one which carries the driving pulleys, gives motion to a vertical shaft B carrying a worm D. The worm gears with a worm wheel keyed on the same shaft as the heart cam A, and thus drives it.

The heart cam is in contact with a lever F, which is depressed and raised according to the part of the cam engaged with it, and controls the speed and position of the lifting rail.

Its action will be easily understood on reference to fig 124. The lever F has a set screw G fixed in it, which at each movement comes into contact with part of a catch lever carrying the paul P. This is engaged with the teeth of a small catch wheel fixed on a short stud. The stud also carries a worm which gears with a worm wheel W borne on the small shaft that carries the lower bowl H. It follows that each descending movement of the lever F moves the ratchet a few teeth, and revolves the worm wheel and chain bowl. The winding and unwinding of the chain raises and lowers the levers K, and consequently the lifting rail supported by them. The yarn is guided from the ring traveller to the bobbin in a similar manner to that in which the roving is delivered by the presser eye of a flyer frame, except that in the throstle the bobbins remain in one horizontal plane and the ring rail lifts, whilst in the flyer frame the bobbin rail lifts and the flyer eye revolves in one plane.

The ring throstle, like all the other machines, has its various parts adjusted according to the yarns being spun. For instance, the velocity of the ring rail is slower for fine than for coarse yarns. The inclination of the axis of the drawing rollers is greater for coarse than for fine, the object of this being to lessen the friction on the thread board. When cotton of very weak staple
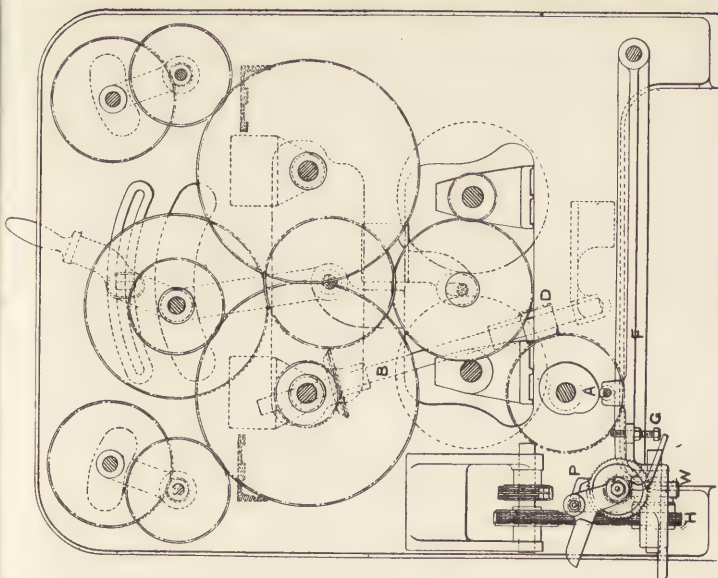
FIG. 124.—TRANSVERSE VIEW OF RING SPINNING FRAME.
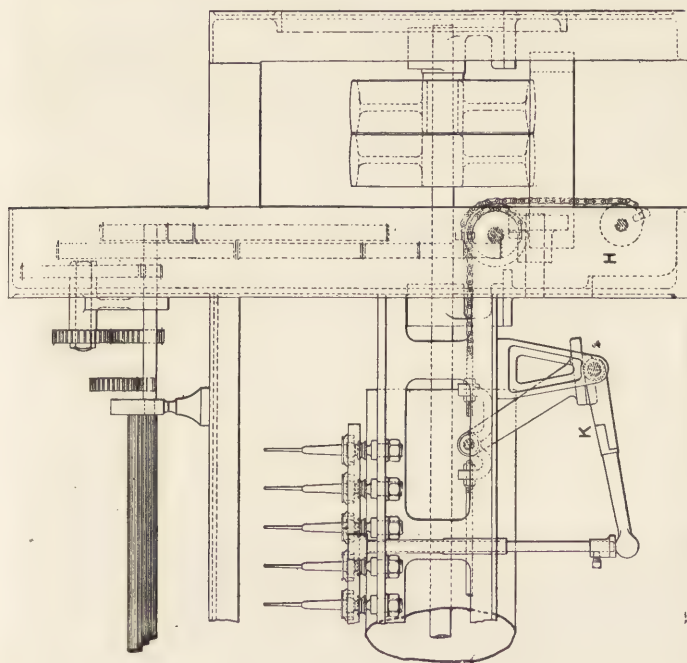
FIG. 124a.—LONGITUDINAL VIEW OF RING SPINNING FRAME.

S

is used, the inclination will be great, as, for example, in the spinning of Indian cotton—twist—when the inclination would be about 35°. In England, for American cotton this would be great enough for weft, whilst 22° is sufficient for twist. It is desirable that the yarn shall receive the twist instantly it leaves the nip of the rollers, on account of the speed and the tension that is put on it. This is especially necessary for soft twisted yarns, such as weft, and the angle of the rollers is therefore made as large as possible for these yarns. The drawing in fig. 123 shows the passage of the yarn from creel to spindles. It will be noticed that the position of the thread board and guide wires is directly over the spindles. When doffing a frame it is necessary to remove the thread board out of the way, so that the attendant can lift the bobbins over the spindle points.

In old frames the 'doffer' had to lift these separately by hand, and they were constantly falling down during the process of doffing. This inconvenience is now overcome on new frames by applying an arrangement by which all the thread boards on both sides of the frame can be raised simultaneously and kept in position as long as required.

One of the methods is illustrated in fig. 125. Bolted to the roller beam B is a bracket with a jaw carrying the handle A, which actuates a small lever D centred on the shaft G, which runs down the whole length of the frame. At intervals along this shaft are fixed levers H, communicating, as shown, with the under side of the thread boards. When the handle A is pulled outwards the levers H move round the central shaft, and their extremities push the thread boards upward. They are secured in that position by means of the notch in the handle A, which fits on the small rod R intended for it.

The spindles used in ring frames are of many types, each maker having his own particular form, but, generally speaking, those of all the great machine firms are very good in working.

The advantages sought for and claimed, although secured in different ways, all tend to the same results. It therefore comes about that they are all self-contained, self-lubricating and flexible, that is, one setting only is required, the spindle assuming its own true centre of gravity. If the spindle be out of balance, or from any cause its axis be not perpendicular, it will rotate just as steadily in that position as if it were perfectly straight. This power of finding its own centre is a most important point in a
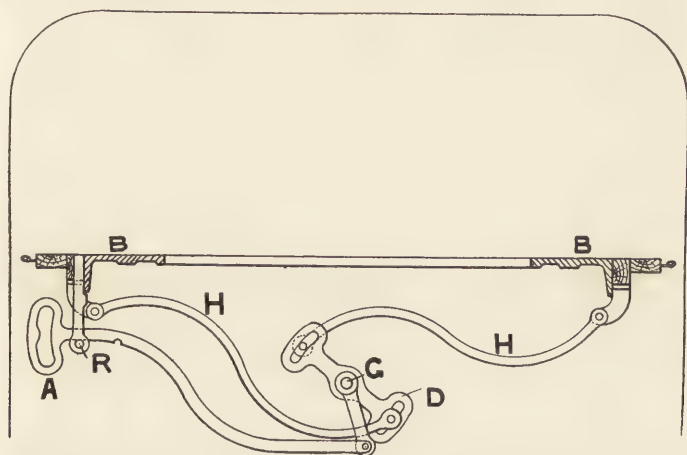
Fig. 125.—Section showing the Arrangement for Lifting the Thread Boards on both Sides of the Ring Frame simultaneously.

ring spindle, and, as stated, 'flexibility' is a feature of almost all new ring spindles. A drawing of flexible spindles by three different makers is given in fig. 126. Another rather important feature of ring spinning frames is the **Anti-Ballooning Motion**, the object of which is to moderate the effects of centrifugal action between the thread board and the ring rail. The portion of yarn between the guide eye of the thread board and the ring traveller forms what is called a balloon, because the motion of the traveller spinning round a ring causes the length of

yarn mentioned to fly outwards and form an inverted 'balloon.'
This ballooning is sometimes sufficient to cause the adjoining
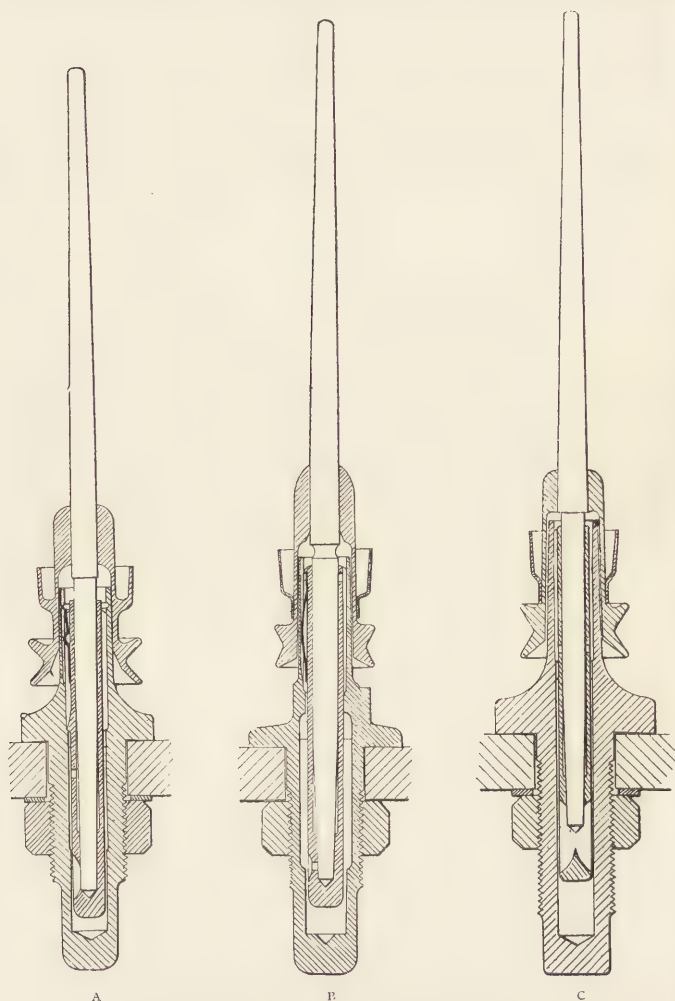
FIG. 126.—THREE SECTIONS OF RING SPINDLES.
A. Dobson and Barlow ; B. Howard and Bullough ; C. Brooks and Doxey.

ends to rub against each other, become entangled, and break. It is evident that the greater the distance between the rollers and the traveller, the greater will be the tendency to enlarge the diameter of the balloon. As the bobbin builds the distance becomes shorter, so that by the time the bobbins are about half built the ballooning is harmless, and the anti-ballooning motion becomes practically useless. It is then removed out of the way.

The object having been explained, it will be easy to understand the sketches. Fig. 127 shows the balloon plate P in elevation and plan with the spindles and ring plate. These are shown in their respective positions, and it will be seen that the plates are horizontally balanced in a certain plane about half-way up the bobbins. This plane is the neutral point where the distance from thread board to travellers becomes too short for ballooning to have any evil effects. Referring to the drawings, R is a long rod running along the frame down both sides and carrying the balloon plates. This rod is square except in the bearings B, which are placed one at every spring piece. The weight of the series of plates is counterbalanced by a corresponding series of weights W placed at convenient distances. This balancing of the anti-ballooning plates ensures that when the ring rail, in the course of building, reaches high enough, it raises the plates and overbalances them, throwing them back, where they remain until required at the beginning of the next set. The attendant can, of course, move the plate out of the way at any time by means of the handle H, which is keyed on the long rod R at the gearing end of the frame. By way of illustrating the practical economy of using balloon plates, it may be stated that for spinning 50's to 70's weft, for instance, a maker would recommend frames of $2\frac{1}{4}''$ space $1\frac{1}{2}''$ ring with balloon plates, but $2\frac{1}{2}''$ space $1\frac{1}{2}''$ ring without balloon plates.
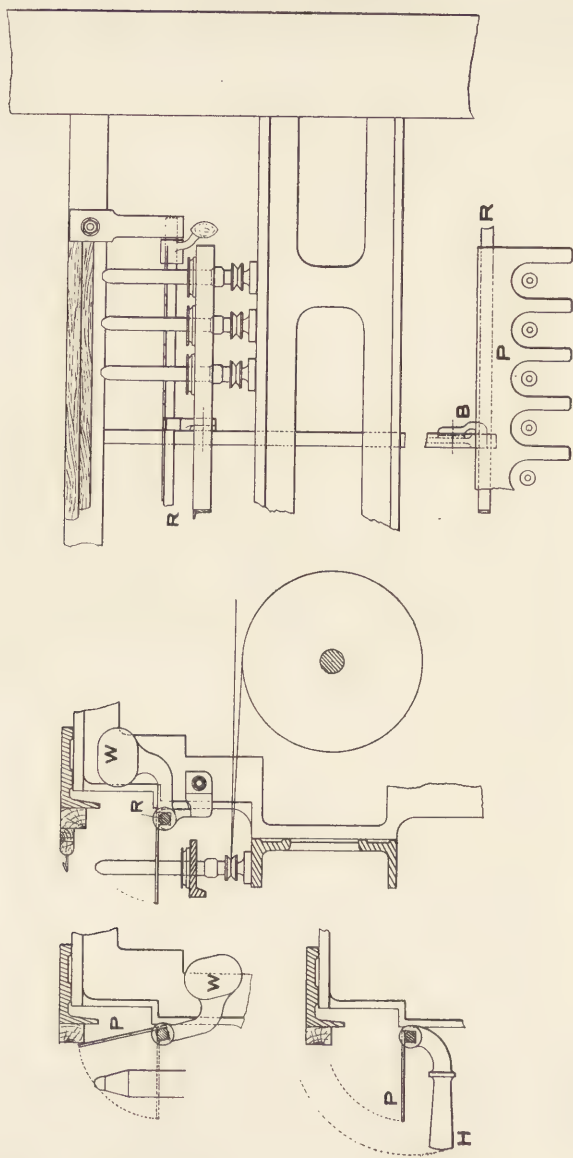
Fig. 127.—Balloon Plate in Elevation and Plan together with the Spindle and Ring Plate.

Calculations on the Ring Frame.—

(1) *First find speed of spindles.*

Line shaft 300 revolutions per minute.

Drum 30″.

Pulley on frame 12″.

$$\frac{\overset{25}{\cancel{300}} \times 30}{\cancel{12}} = 750, \text{ speed of pulley.}$$

Tin drum = 10″.

Spindle wharve = $\frac{7}{8}$″.

$$\frac{750 \times 10''}{\cdot875} = 8571, \text{ or } 8570 \text{ roughly, speed of spindles.}$$
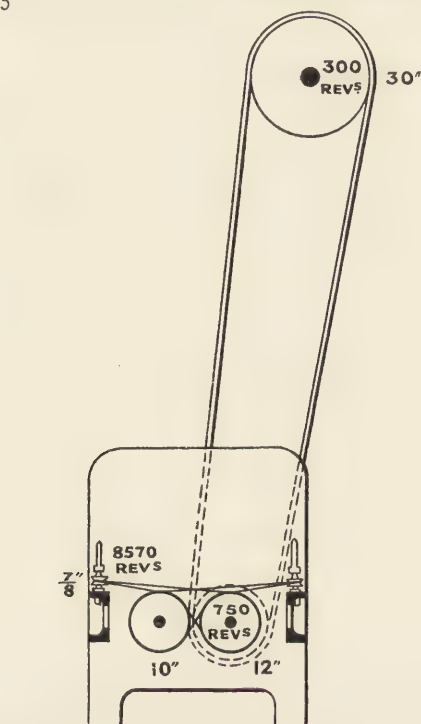
FIG. 128.—SECTION SHOWING THE DRIVING OF SPINDLES IN THE RING THROSTLE.

(2) *Twist on ring frame.*—The following is the strictly accurate method of finding twist on the ring frame :—

Diameter of ring frame front roller, $1''$; diameter of empty bobbin, $1''$; diameter of full bobbin, $2''$; revolution of front roller per minute, 120. Revolution of spindles per minute, 8000.

From these particulars find (1) inches delivered from front roller per minute ; (2 and 3) circumference of full and empty bobbins ; (4) revolutions per minute lost by traveller in winding these inches upon empty bobbins ; (5) the same for full bobbins ; (6) revolutions per minute made by traveller in winding these inches upon empty bobbins ; (7) the same for full bobbins ; (8) the twist per inch put in the yarn for empty bobbin ; (9) the same for full bobbin.

(1) $3.1416 \times 120 = 376.992$ inches per minute.

$$\text{Say } 377.$$

(2) $3.1416 \times 1 = 3.1416$ circumference of empty bobbin.

(3) $3.1416 \times 2 = 6.2832$ circumference of full bobbin.

(4) $\dfrac{377}{3.1416} = 120$ revolutions lost by traveller for empty bobbin.

(5) $\dfrac{377}{6.2832} = 60$ revolutions lost by traveller for full bobbin.

(6) $8000 - 120 = 7880$ actual revolutions of traveller for empty bobbin.

(7) $8000 - 60 = 7940$ actual revolutions of traveller for full bobbin.

(8) $\dfrac{7880}{377.0} = 20.9$ twist per inch for empty bobbin.

(9) $\dfrac{7940}{377} = 21.06$ twist per inch for full bobbin.

The foregoing calculations are given to show that the twist per inch depends upon the revolutions per minute of the traveller, and that there are more for the full diameter of the bobbin than

for the empty bobbin, and the method of finding twist on the other machines is not strictly accurate for ring frames.

For practical purposes, however, the usual rule as given below is quite good enough.

Rule.—Multiply all the driving wheels, the diameter of spindle wharf, and the circumference of the front roller together, for a divisor. Take for a dividend the product of all the driven wheels and the diameter of the tin roller.

Tin roller wheel . . . . . . 40 teeth
Driving a bottom stud wheel . . . . 85 ,,
On same stud is twist wheel . . . . 30 ,,
Driving through carriers the front roller wheel . 80 ,,
Diameter of tin roller . . . . . 10 inches
    ,,   spindle wharf . . . . . $\frac{7}{8}$ inch

$$\frac{85 \times 80 \times 10 \times 8}{40 \times 30 \times 7 \times 3\cdot1416} = 20\cdot6 \text{ turns per inch.}$$

If the 30 twist wheel be left out, it will give us the constant number for twist, and this number being divided by any required twist wheel will give the resulting twist per inch; or divided by any required turns per inch it will give the proper twist wheel.

Example.—

$$\frac{85 \times 80 \times 10 \times 8}{40 \times 7 \times 3\cdot1416} = 618 \text{ constant.}$$

(3) *Twist wheel.*—What twist wheel must we put on to give 24 turns per inch?

$$618 \div 24 = 25\cdot75, \text{ say 26 twist wheel.}$$

(4) *Changing counts.*—The following is a typical calculation when changing counts :—

We are spinning 40's with a 30 twist wheel, a 40 change pinion, and a 35 builder wheel. Find wheels for 32's.

1. Twist wheel.

Rule.—Multiply wheel on by square root of counts spinning, and divide by square root of counts required.

$$\frac{\sqrt{40} \times 30}{\sqrt{32}} = \frac{6 \cdot 32 \times 30}{5 \cdot 65} = \frac{189 \cdot 6}{5 \cdot 65} = 33 \cdot 5, \text{ say 34 twist wheel.}$$
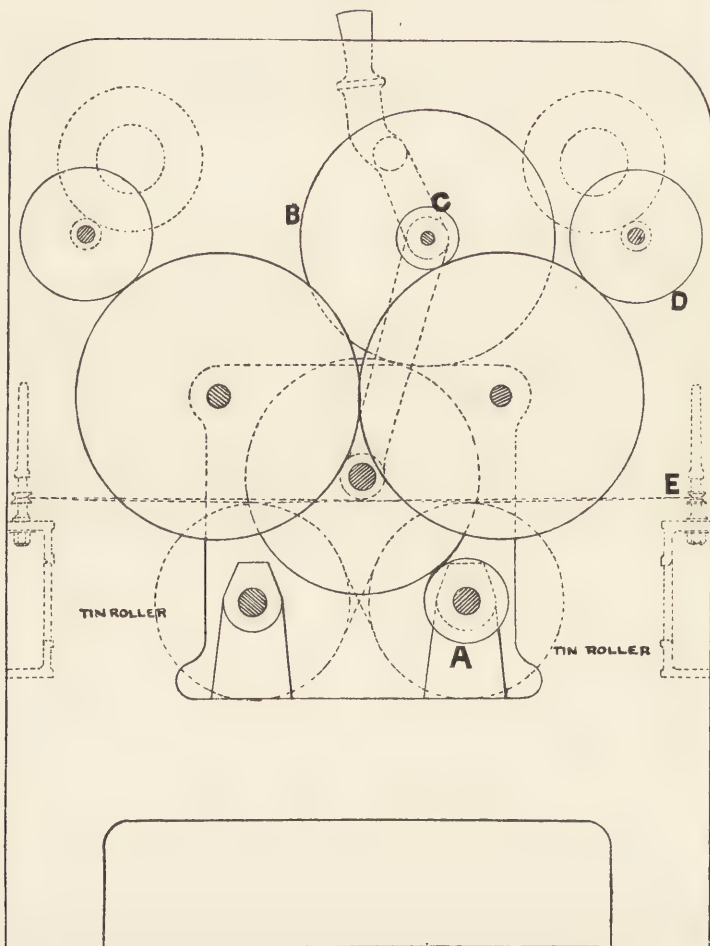
FIG. 129.—END VIEW SHOWING GEARING OF RING SPINNING FRAME.

2. Change pinion.

Rule.—Multiply present counts by present wheel and divide by counts required.

$$\frac{40 \times 40}{32} = 50 \text{ change pinion.}$$

3. Builder wheel.

Rule.—Multiply present builder wheel by square root of counts required, and divide by square root of counts now spinning.

$$\frac{35 \times \sqrt{32}}{\sqrt{40}} = \frac{35 \times 5\cdot65}{6\cdot32} = 31\cdot28 \text{ builder wheel.}$$

The weight of traveller would need changing, say from 10/o's to 5/o's.

(5) *To find draft.* *Rule.*—Divide the product of front roller wheel and change wheel into the product of crown wheel and back roller wheel. If the diameters of back and front rollers are not alike, then the diameter of front roller goes in dividend, and diameter of back roller goes in divisor.

Example.—A 20, on front roller, drives a 70 crown wheel, and a 36 change pinion drives a 60 back roller wheel. The diameter of back and front rollers are alike.

$$\frac{70 \times 60}{20 \times 36} = 5\cdot83 \text{ draft.}$$

Take the same wheels with an inch front roller and a $\frac{7}{8}$ths back roller.

$$\frac{70 \times 60 \times 8}{20 \times 36 \times 7} = 6\cdot66 \text{ draft.}$$

If the change pinion were left out it would give us the constant for draft.

Example.—

$$\frac{70 \times 60 \times 8}{20 \times 7} = 240 \text{ constant.}$$

What change pinion would be required to give 8 of a draft?

$$240 \div 8 = 30 \text{ change pinion.}$$

CHAPTER XVIII

Uses of Spun Yarn.—The uses to which yarns are put are principally for weaving and doubling. The first includes the manufacture of cotton cloths and the partial manufacture of other cloths, such as, for instance, cloth consisting of cotton warp and woollen weft, a very common production. The second branch—doubling—comprises the doubling and twisting together of yarns for the manufacture of sewing thread, knittings, crotchet cotton, hosiery nets, embroidery yarns, and lace.

In weaving two classes or kinds of yarn are needed : twist, which forms the warp threads of a fabric ; and weft, which forms the filling or cross threads put in by the shuttle. The first of these requires considerable preparation for the loom, while, on the other hand, weft requires little or none, the cops from the mule or bobbins from the ring frame being generally placed in the shuttles without any previous unwinding. For the purposes of doubling, which it is intended to deal with more particularly, the usual course is to prepare the yarn for doubling by winding it on suitable large bobbins or tubes for the doubling frame creel.

The manufacture of sewing thread, and, indeed, of all the other yarns mentioned, comprises some difficult and responsible operation. The varied uses of these goods cause the business to be a most complicated one. The instructions which accompany orders given to doubling firms are very precise, and a

small variation from the amount of twist or the required strength of the thread is sometimes a serious matter.

The yarn is usually doubled by two operations, as it is
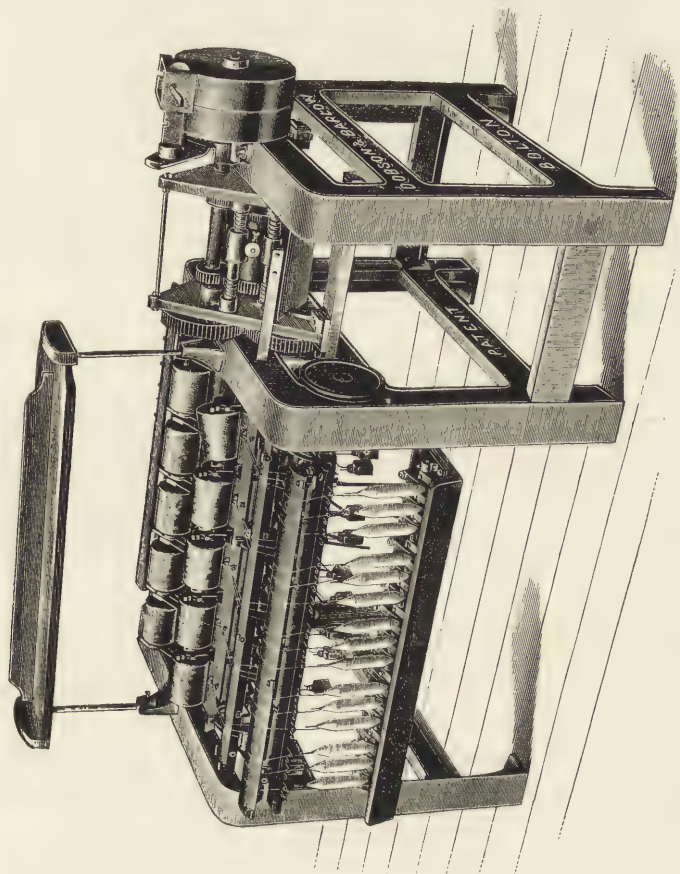
FIG. 130.—QUICK TRAVERSE WINDING FRAME.

mostly composed of six or nine strands twisted together to form '6-cord' or '9-cord' thread. The first doubling is called 'preparing,' and the second 'finishing,' each process being

preceded by a Doubling Winding Frame, such as is shown in fig. 130, and in section in fig. 131. The object of this machine is really to 'double' the yarn, whilst that of the doubling frame is to twist it. Before the twisting of the ends together can be properly accomplished, it is necessary to ensure that the tension of the threads doubled together shall be uniformly
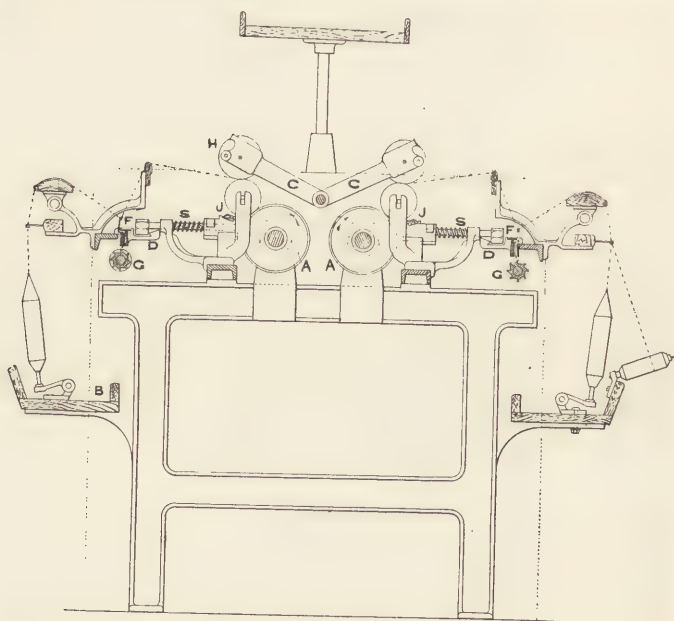
Fig. 131.—Section of Quick Traverse Winding Frame showing Stop Motion.

equal, or a poor 'screwy' thread will be made. If yarn is doubled from cops, the drawing off from a surface of varying thickness will cause the ends being doubled to constantly overrun each other, and when this occurs the slack end will warp round the tight one in irregular coils, owing to uneven tension. The evil is even more apparent when three or more

ends are being twisted together. This effect is called 'cork-screwing,' and is avoided by first doubling the threads on the winding, as already mentioned. The machine in the illustration is called the 'Drum' Winding Frame, because the system of winding is that of frictionally driving the spools by contact with circular bobbins, as will be explained.

In the ordinary winding frame, such as is used for preparing twist for weaving, the yarn is wound on to bobbins placed on spindles. These spindles are absent in the machine under notice, being replaced by the drums A, which are generally about $5\frac{1}{2}''$ diameter, or $17\frac{1}{4}''$ circumference. They are positively driven from the driving by wheel gearing. The bobbins from the ring frame, or cops from the mule, are placed in the creel B, and the ends of yarn are guided from them to the spool, as shown.

Each end passes over a thread board, then through a small wire hook F, and is then guided over a rail to the spool or bobbin H. The spool rests upon a circular wooden roller, which conveys the motion from the metal drum A. It is usual to apply a quick traversing motion to this machine, so as to cross-wind the yarn on the spool, the advantage being mainly to get more yarn on each spool and thus render creeling in the doubler less frequently necessary. The spools are without heads, and are $3''$ to $6''$ traverse ; they are easily placed in the doubling frame creel, which contains steel pegs for their reception, as may be seen on reference to the illustration of Doubling Frame (fig. 132). The drums of the cross-winding frame revolve in the direction indicated, and drive the wood rollers and the spools, which are carried in loose arms C. Any number of ends from one to six are doubled by this machine, being combined together after passing the thread board and detector hooks F. Every single thread is provided with one of these hooks, which are held in suspension as shown, and when an end breaks its hook falls down instantly, and the tail comes
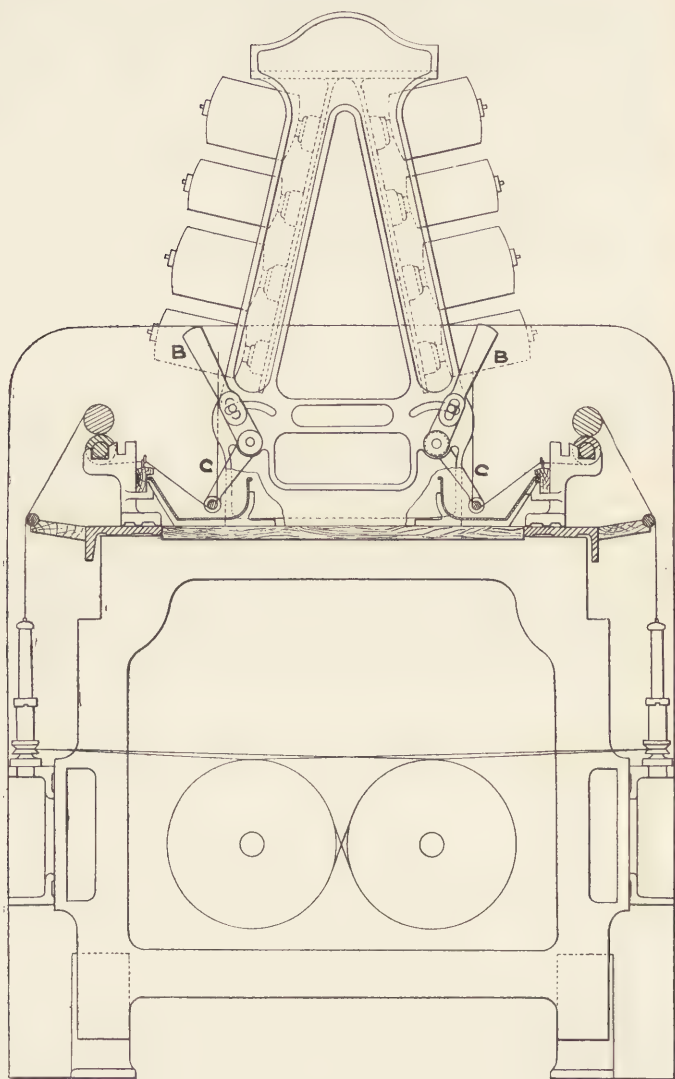
FIG. 132.—SECTION OF DOUBLING FRAME

into the teeth of a revolving wiper G, which carries the wire forward, and by pressing it against the sides of the niche in the hinged lever D oscillates the latter. The movement of the lever releases a stop rod S (previously held in tension by means of a spiral spring), and, allowing it to slide forward, places a wooden break J against the carrier roller, thereby preventing any further revolution of the spool until the end is pieced up and the wire hook again suspended. There is one break to each drum, so that when an end fails the stop motion acts only on the particular drum and bobbin affected. As this stop motion is almost instantaneous, a breakage is discovered at once, and yarn consisting of fewer than the desired number of strands cannot be passed. The advantages of this to the doubling process cannot be over-estimated.

The Winding Frame Creel is arranged to wind from cops, hanks, or bobbins, and to make parallel or cone-shaped bobbins, or bobbins with tapered ends. The parallel spools are easily made up to 9″ diameter.

We now come to the consideration of the doubling frame, or, more correctly speaking, the twisting frame. There are three kinds of doubling frames : the flyer frame, the ring frame, and the twiner. The first of these needs no separate description, being similar in general principle to the flyer throstle, and sufficiently like the other continuous doubler, the ring frame, to be understood from the description of the latter.

The Doubling Frame.—In fig. 132 is shown the section of a ring doubling frame, fitted with what is called a porcupine creel to hold the spools from a drum winder. The object of this machine being to twist the yarn, there are no drawing rollers, as in spinning machinery. The threads are therefore simply led off from the spools through a guide-rail and one pair of weighted rollers to within the sphere of action of the spindles and traveller where the twist is introduced. The drawing

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represents a 'Wet' doubling frame, as it is called.   This is the
most usual type, because all thread is 'wet-doubled,' that is, is
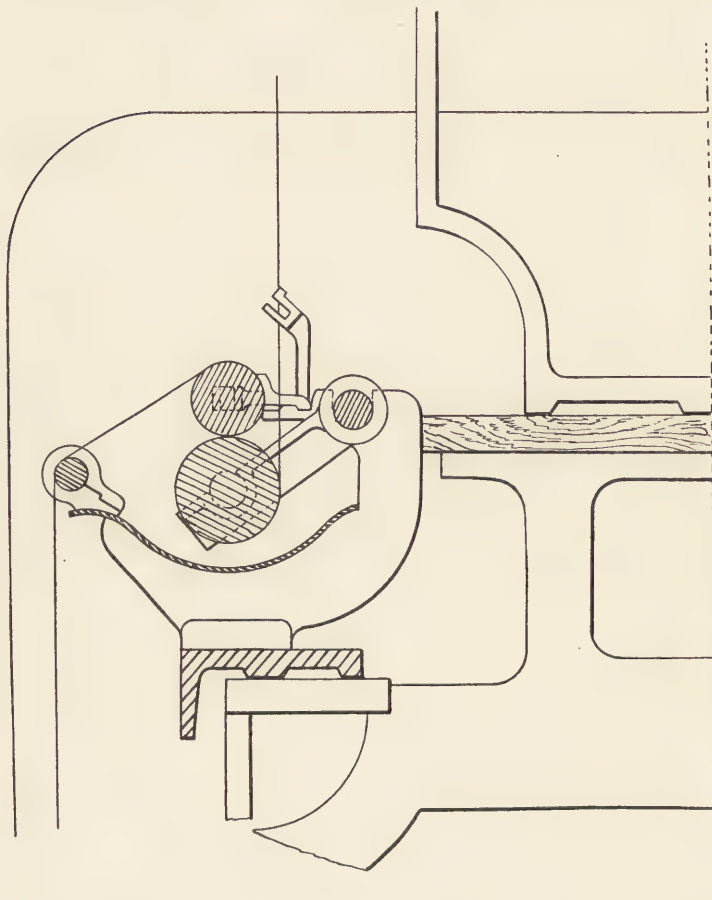
FIG. 133.—SECTION OF DOUBLER SHOWING THE SCOTCH SYSTEM OF DOUBLING.

saturated with water before being twisted, so as to harden and
stiffen the thread.   Dry doubling is mostly used for doubling
warp yarns for weaving purposes.   The section, it may be

remarked, is that of a doubler on the English system, and may be compared with (fig. 133) the part section of a doubling frame on the Scotch system. The difference of the two is found in the position and shape of the water trough, and in the position of the rollers with respect to the trough.

In the English Doubler (*see* fig. 132) the rollers are carried on stands fixed to the roller beam, the threads being saturated on passing under a glass rod covered with water. An arrangement is fitted for raising the glass rod out of the water for cleaning and other purposes. It consists of a handle B moving in a radial slot, and forming one arm of a lever B C. This is too simple to require further explanation, as it can easily be followed from the drawing. With reference to the Scotch doubler (fig. 133), the threads are passed first beneath the rollers, and then between them, the bottom roller being partly under water. The bottom rollers are made in long lengths and carried in small but stout brackets fixed to a shaft running the whole length of the frame, and they can be raised and lowered at will. It must of course be understood that the top and bottom rollers are covered with brass, and the brackets carrying them are made of brass, as are also the bolts used to connect the troughs to the roller beams. The troughs themselves are made of copper, and are soldered together to form one long length. The last remark refers more particularly to Scotch doublers. This trough is fitted with a water tap at one end to facilitate the emptying. Many doublers are at work with short earthenware troughs, long enough for about twenty ends, and some are even fitted with wooden troughs. Generally speaking, these are becoming obsolete. The doubler shown in full section is furnished with a creel of four heights, but it is not uncommon to see them with six rows of pegs for bobbins when several ends are being twisted together.

The Ring Doubler has, on account of its heavy

ROLLER BEAM
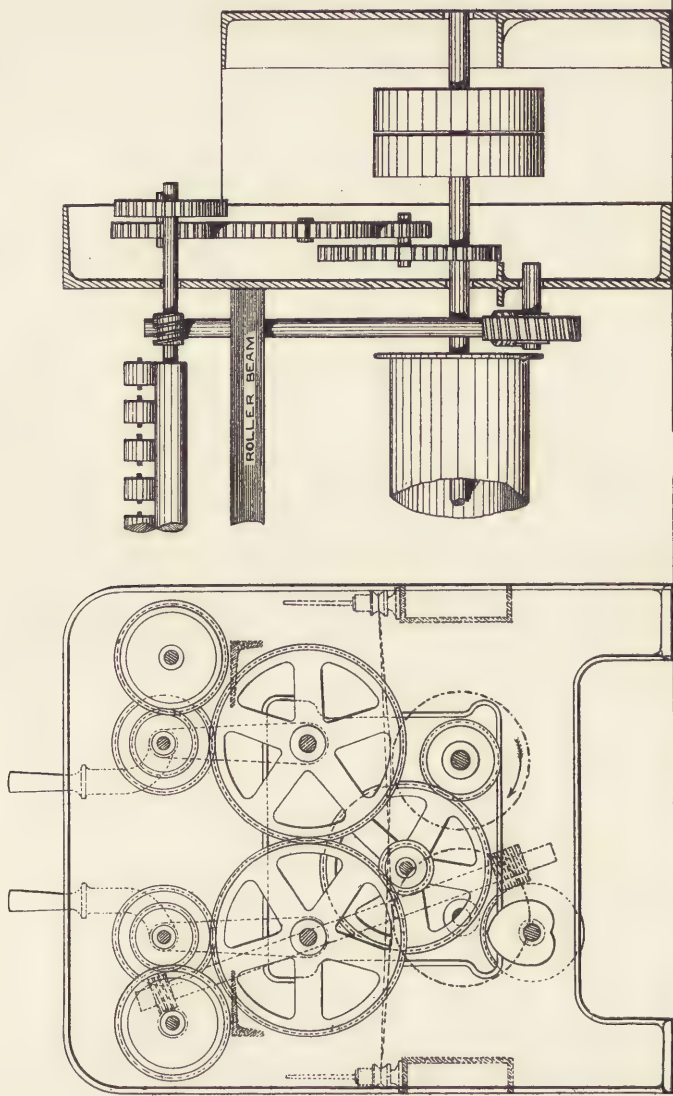
Fig. 134.—End View and Sectional Elevation of Ring Doubling Frame.

production, almost displaced the flyer doubler, except for coarse counts. The yarn produced by a flyer frame is rounder and more uniform than that produced by the ring frame, and it is consequently the proper machine for heavy yarns, which would, if doubled on rings, show a flattened side on the threads. The evenness of the work from the flyer frame more than compensates for the low production. When 6-cord thread or crotchet cotton is being made, two doubling frames, as already mentioned, are necessary. The first, the ' preparing ' frame, is succeeded by the re-winding frame, which is identical with the winding frame already described, and serves the same purpose. It doubles the yarn for the finishing frame.

The Finishing Doubler, as its name implies, finishes the manufacture of the thread, and the subsequent processes depend to a large extent on the ultimate object of the yarn, which may be intended for lace, hosiery, sewings or crotchet cotton. Two views of the gearing of a ring doubler are given in fig. 134.

The Twiner.—The twisting machine known as the twiner is made in two forms, both of which, however, are a modification of the spinning mule, and require the same motions of spinning, backing off, and winding. The type most commonly used in this country is the ' Yorkshire ' twiner, which differs from the mule in having the tin roller carriage and spindles stationary, whilst the creel travels outwards and inwards. In this machine the rollers are entirely dispensed with ; the ends pass from the cops in the creel through a wet list cloth, which cleans the yarn, then through a trough under small earthenware weights, and finally within the range of action of the spinning, this of course resembling the spinning of the mule exactly. When the twiner gets out at the end of its stretch the threads are held during backing off and winding by means of brass slides. As it reaches the stops

at the end of winding the slides rapidly unlock and allow the threads to be unwound again. This machine doubles from cops and makes the yarn into cops. Its use dispenses with the winding frame, because corkscrewing, &c., are prevented from occurring by means of the wet listing board where the ends are combined. On the other hand, the production only slightly exceeds that of the mule and falls short of the ring frame. The quality of the yarn produced by the twiner is, however, better, but, generally speaking, for medium and medium fine counts the ring frame is preferred, because of production.

The other twiner, known as the 'French' Twiner, is more nearly identical with the mule, because the receding carriage comprises the spindles, tin rollers and fallers, as in the mule, whilst the creel remains stationary.

Doubling Calculations.—(1) *Doubler production.*—A doubling frame is doubling 60's 3-cord sewing thread and putting in 29 turns per inch. The speed of the spindles is 7,000 revolutions per minute, and the machine runs 54 out of 56½ hours per week. How many hanks per spindle are being produced weekly? (Union of Institute's Exam.)

$$\frac{60 \times 7000 \times 54}{29 \times 12 \times 3 \times 840} = 25 \cdot 86 \text{ hours per spindle.}$$

N.B.—The 12 and 3 in the divisor are used to bring the inches to yards, and the 840 to bring the yards to hanks.

(2) *Revolutions of spindles.*—On a doubling frame the revolutions of line shaft are 210 per minute ; diameter of drum on line shaft, 30″ ; diameter of frame end pulleys, 10″ ; tin roller diameter, 10″ ; diameter of spindle wharf, 1″. Find revolutions of spindle per minute.

$$\frac{210 \times 30 \times 10}{10 \times 1} = 6300 \text{ per minute.}$$

(3) *Revolutions of front roller.*—To find revolutions per

minute of front roller of doubling frame. Revolutions of tin roller per minute, 250. Tin roller wheel, 30 teeth ; driving stud wheel, 70 teeth. On same stud, bottom twist wheel, 20 teeth ; driving through carries a 40 stud wheel. On same stud top twist wheel, 35 teeth ; driving front roller wheel, 50 teeth.

$$\frac{250 \times 30 \times 20 \times 35}{70 \times 40 \times 50} = 37\cdot5 \text{ revolutions per minute.}$$

Taking the diameter of front roller to be 2″, then the inches delivered per minute would be :

$$3\cdot1416 \times 2 \times 37\cdot5 = 235\cdot6.$$

When the inches delivered per minute and the revolutions of spindle per minute are found, we need only divide inches into revolutions to get the twist per inch. Take the two preceding answers.

$$6300 \div 235\cdot6 = 26\cdot7 \text{ turns per inch of twist.}$$

(4) *Resultant counts.*—When two or more yarns of the same counts are doubled together, to find resultant single counts we may divide the single counts by the number of folds.

Thus twofold forty's or 2/ 40's = 20's
threefold ninety's or 3/ 90's = 30's
fourfold hundred's or 4/100's = 25's

Strictly speaking, when yarns are doubled together the resultant counts will be somewhat coarser than what is given by above rule, on account of contraction by the twist.

When two yarns of different counts are doubled together a good rule is, 'Divide their product by their sum.' Another rule is, 'Take the weight of a lea of each, add them together, and divide into 1000.' This latter rule is also perhaps the best method of ascertaining counts when three or more yarns of different numbers are doubled together.

Example 1.—30's and 20's are doubled together. Find resultant counts.

$$\frac{30 \times 20}{30 + 20} = 12\text{'s,}$$

or a lea (120 yds.) of 30's weighs $1000 \div 30 = 33\cdot\dot{3}\dot{3}$
    a lea of 20's weighs $1000 \div 20 = \underline{50}$
$$83\cdot\dot{3}\dot{3}$$

then $1000 \div 83\cdot\dot{3}\dot{3} = 12$'s, as before.

Example 2.—Find the resultant counts when 120's, 80's, and 40's are doubled together.

grains.
A lea of 120's = $1000 \div 120$'s = $8\cdot3\dot{3}$
A lea of 80's = $1000 \div 80$'s = $12\cdot5$
A lea of 40's = $1000 \div 40$'s = $\underline{25\ 0}$
$$45\cdot8\dot{3}$$

$$\frac{1000}{45\cdot8\dot{3}} = 21\cdot8.$$

Another rule for the same thing is, 'Divide the highest count by each of the others and by itself. Then divide the sum of the quotients into the highest count.'

To find the counts which must be doubled with another to produce a given count, divide the product of the two counts by their difference.

Example.—What counts must I double with 50's to produce 20's?

$$\frac{50\text{'s} \times 20}{50 - 20} = 33\cdot\dot{3}\text{'s.}$$

Note.—It is very seldom that yarns of different counts are doubled together, as this system does not give as good a doubled thread as by keeping to one counts.

(5) *Percentage waste.*—Out of 4000 lbs. of yarn that are reeled there are 48 lbs. of waste. How much is that per cent.?

$$\frac{100 \times 48}{4000} = 1\cdot2 \text{ per cent.}$$

The process which follows that of doubling in a mill depends, as has been remarked, on what the thread is intended for. Yarns used for sewings, knittings and lace, and, indeed, almost all particular yarns, are 'cleared,' as the process is called, and a great many yarns are 'gassed' in addition. These machines, with the reel and the bundling press, may be said to complete the ordinary outfit of a doubling mill. They will now be noticed in more detail, and their purposes explained.

The Clearing Frame.—The work of the clearing machine consists in clearing knots and other obstructions from doubled yarn. It is a form of winding frame, and winds the yarn from doubler bobbins on to window bobbins, but the threads are passed through fine slits in a metal rail. These slits are large enough to allow good yarn to pass through them, but are too small for knots or other lumpy places to pass. When these obstructions do occur the revolution of the bobbin, which is frictionally driven, is stopped, and the attention of the workhand being thus called to it, she removes the lump. If it is a knot, say a bad doubler's knot, she has to take it out and re-connect the separate strands forming the cabled thread, so as to make the yarn smooth and uniform.

Clearing, it will be noticed, is necessary for all threads that are intended to pass through the eyes of needles, as sewing thread for hand and machine. The clearing frame is much the same in principle and construction as the ordinary winding frame used in weaving preparation. It has vertical spindles, which are placed in two rows on each side of the frame. They revolve at 700 to 900 revolutions per minute, according to the class of yarn. The requirements of the latter make the clearing process a very important one, some yarns needing much more care and supervision than others. Further, the uniformity of the yarn itself affects the clearing process, and carded yarns are often passed through a coarse clearer, and afterwards through a

fine clearer. The next stage in the manufacture of the thread is the removal of the filaments, or 'lint,' from the surface of the thread. This is done by a simply constructed machine called the Gassing Frame.

The Gassing Frame.—This machine is represented in fig. 135. It is one of the newest type, viz.: Dobson and
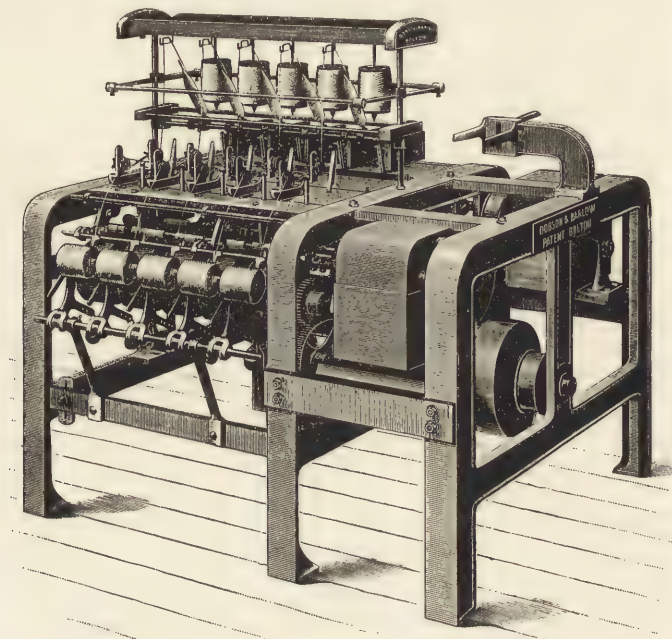
FIG. 135.—QUICK TRAVERSE GASSING FRAME.

Barlow's quick traverse gassing frame. It is so called because, like the doubling winding frame (fig. 135), it makes spools or 'cheeses,' on headless bobbins, by cross-winding the yarn through a quick traversing rail. The thread is led off from the bobbins in the creel and passed over two small grooved pulleys, between which is a small gas flame. The yarn is run through

the light very rapidly, so as not to burn it, and it requires several passages through the frame to sufficiently treat it. For this purpose the two small pulleys mentioned have several grooves each, so that the yarn can be threaded over one and under the other, and *vice versa*, repeatedly, until the requisite number of crossings is obtained. To effectually bare the thread, the number of times through the light varies from five to eleven. The main gas pipe which supplies the burners runs along under the frame, and is connected to the burners by separate short lengths. Each thread is furnished with a contrivance by which the burner is moved laterally away from the path of the yarn, to allow for piecing up, &c. It will be understood that gassing is an important operation and must be managed carefully. Whilst good gassing effectually bares the yarn, too much gassing will ruin it. When this process is finished the thread may be said to be fully made. The succeeding manipulations come under the head of thread finishing.

Reeling, &c.—The reeling machine is a very widely used one, and exists in various forms, the object of each being the same, namely, the winding of yarn from cops, bobbins, or spools into 'hanks,' for economy and handiness of carriage. It is therefore found in ring spinning mills as well as in doubling mills.

In fig. 136 we are enabled to show, by the kind permission of Mr. Stubbs, Manchester, a double bobbin reel intended for reeling yarn from ring spinning or ring doubling bobbins into hanks. The yarn is drawn from the bobbins over a guide eye and clearing rail to a swift or light cylinder of wood. The revolution of the swift draws or reels the yarn round its circumference, which is 54″. The advantage of reeling in this manner on a measuring swift is evident, for 560 revolutions will reel 560 threads or 1 hank of 840 yards. The machine is fitted with a 'knocking off' or stop motion, which is adjustable, but is usually
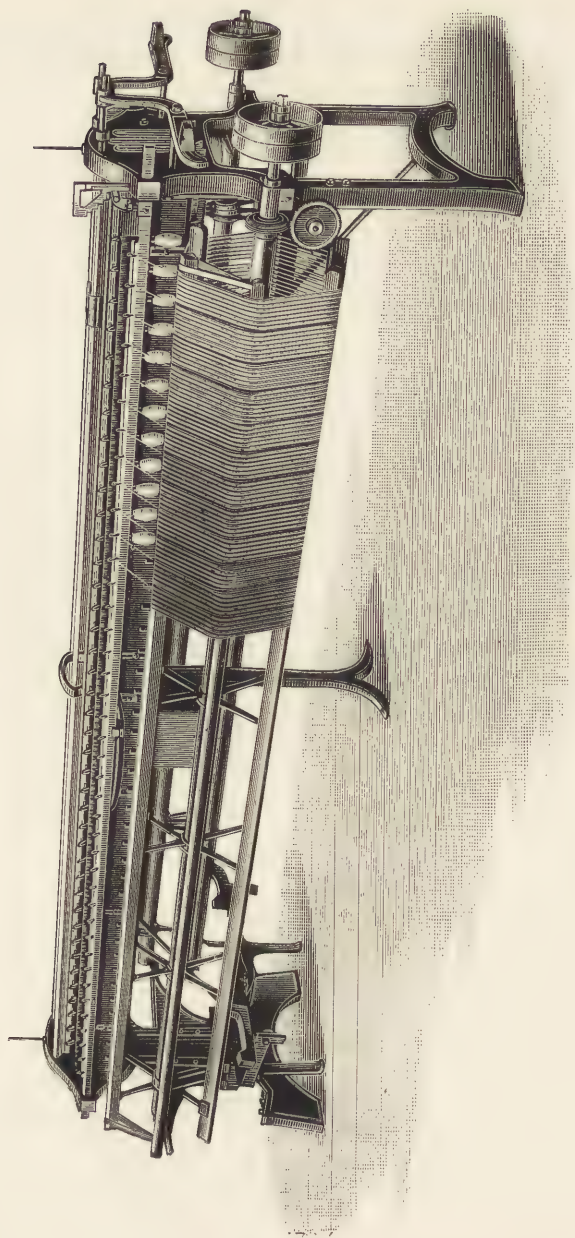
Fig. 136.—Double Forty Hank Bobbin Reel by Stubbs, Manchester.

FIG. 137.—SINGLE FORTY HANK COP REEL, BY STUBBS, MANCHESTER.

arranged to stop the reel when 7 leas have been wound on to the swift. Referring to the figure, it will be seen that a number of hanks are reeled simultaneously. This number is usually 40 on to a single reel, or 80 on to a double 40-hank reel, as shown. When the yarn comes to be bundled, it follows that a certain number of hanks from the reels are packed together to form a bundle of a given weight, say 10 lbs., because the number of pounds multiplied by the number of counts of the yarn will give the number of hanks necessary to make one bundle.

When the reel is stopped for doffing, the attendant 'ties' the hanks, so that each remains compact and separate. The principal detail motions of a reel are in connection with the doffing and the method of reeling. Of the latter class the most general rule is to wind in 7 leas automatically divided, but when the yarn is intended to be dyed or bleached 'in the hank,' it is usual to cross-wind the yarn on the swift by means of a traverse.

Another reeling machine, viz. a single 40-hank cop reel made by Stubbs, Manchester, is shown in fig. 137. This is a very widely used reel, but the only material difference is in the arrangement of the creel, which is designed to hold cops instead of bobbins. It is hardly necessary to state that this is a single reel, because it has one swift, whereas the one in fig. 136 is a double reel and has two swifts.

The Bundling Press.—Fig. 138 is the machine used to form and press the bundles of yarn for export or other carriage. It is the final operation performed on the yarn in most mills, and therefore forms part of the warehouse outfit. The upper part of the machine is called the yarn box; into this a number of hanks, viz. enough to weigh 5 or 10 lbs., as the case may be, are placed, and the top rails closed down securely. Previous to placing the yarn in the box a number of strings, generally

four, are threaded through the divisions shown for the purpose
of tying up the bundle. When the machine is started, the
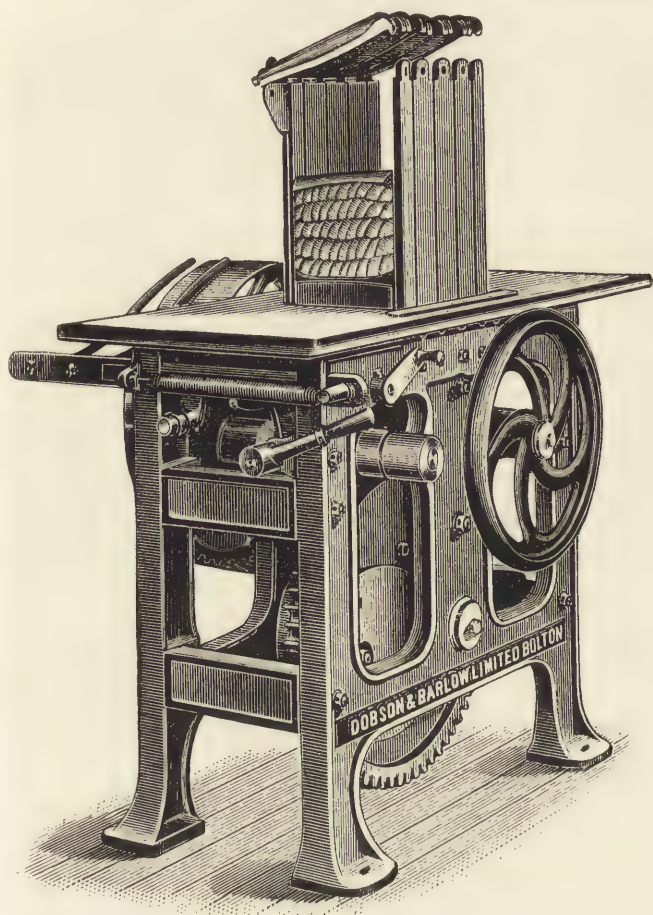
Fig. 138.—Yarn Bundling Press.

plate forming the bottom of the yarn box is raised up by means of two powerful cams, thus compressing the yarn into a small space, when it is tied and taken from the machine. This machine is adapted to make square, or oblong, bundles of yarn, and will press 1,800 lbs. per day of 10 hours.

CHAPTER XIX

Common Derangements of Cotton Machinery and Remedies. Some Practical Notes on Openers and Scutchers.

Lap Roller Sticking.—In starting a new opener or scutcher it will often conduce to the successful working of the machine if the various parts against which the raw cotton is liable to impinge are black-leaded, so as to be smooth. For example, the front rollers on which the lap roller revolves may be black-leaded as well as the lap roller itself, to ensure the latter being freely withdrawn from the inside of the lap. In some cases the lap roller will stick to the inside of the lap on Monday mornings, or at any other time after the stoppage of the machinery for any length of time. A good thing to do is to rub the roller well with French chalk, as this will not discolour the cotton, like black-lead, although it is perhaps not quite so effective.

Catches.—Every precaution should be adopted to ensure that the cotton does not *catch* on the sides of the passages from the beater to the cages, or on the cage dust bars. Any point to which cotton can be attached in the passage to the cage will certainly tend to form what is known as a 'catch,' and this stringy portion of cotton as a rule affects the edge of the lap and tends to produce a bad selvage. This is explained by the fact that the 'catches' invariably divert the cotton from being

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placed on or near the edges of the cage. If bad selvages are being made attention should at once be paid to this point.

Cone Belt Slipping.—In starting a machine of this class there is frequently a tendency for the cone belt to slip, with the consequence of a thinning of the resultant lap.

This is caused by the fact that delivery is going on as usual, while the feed is temporarily stopped. Bearing in mind that the concave cone is the driver, and the convex the driven, and that the latter is always connected with the feed rollers, it will be quite clear that though the concave cone may start promptly, yet if the belt slip the convex cone cannot start the feed of cotton properly. Occasionally the convex cone may not start at all, particularly if the belt be very slack, in which case the lap will break off entirely, owing to the cotton ceasing to come through the cages. In such a case immediate tightening of the belt should follow. Narrow cone belts are the best for ensuring regularity in laps, provided they are sufficiently wide to do their work. Various appliances are common for automatically tightening the cone belts.

Lap Licking.—When adjacent layers of a cotton lap adhere together in unrolling, this is called 'lap licking.' This may happen either at the back of the card or in the creel of the scutcher. Two things may result when lap licking occurs, viz. uneven sliver and making of waste. In the spinning of waste cotton it is sometimes so serious as to necessitate the use of drag boards, or the running of rovings in with the lap. The drag board may be hung to the sides of the machine at the front, so as to impinge on the lap as it is being formed, and to have a calendering effect upon it. In the case of the rovings a light wooden creel may be made and secured to the framing in front of the calender rollers. It may be arranged to carry about six slubbing bobbins, and the ends from these can either be passed directly upon the lap, or they may be first passed

through the calender roller along with the cotton. As they are rolled round with the lap they keep each layer of cotton quite distinct. It might be supposed that the slubbing ends would do some damage to the card clothing, but the action of the taker-in will effectually prevent any such contingency. Some suppose by making the upper cage larger than the lower one that this is an effective preventative of lap licking. There is, however, much difference of opinion upon this point, and the cages of modern scutchers are sometimes alike in diameter, and in others the top cage is the larger. Then, again, lap licking is caused by mixing long and short staple cottons together. The short fibres are placed first on the cages, because of their lighter character, and form the outside of each layer. Thickening the lap is sometimes resorted to, to prevent lap licking, but this is to be deprecated, as draft disarrangements will follow.

Starting the Cotton.—Openers and scutchers are generally run bare and well cleaned at the week-end. The next time the cotton is put through it will often accumulate at the back of the calender rollers instead of coming forward through the bottom pair of rollers. It is a somewhat dangerous practice to get beneath the machine and pass the cotton forward, and instead of doing so it is common in the mills to spit on the two bottom calender rollers, so as to cause the cotton to stick to them. It occasionally happens that the breakage of a cone belt causes the entire failure of the feed, in which case the cotton has always to be conducted through the machine afresh, as indicated previously. In cases where the cotton has been allowed to extensively accumulate between the calender rollers and cages, the method of weighting the former by levers and weights is seen to advantage, as this method allows the rollers to accommodate themselves to varying conditions without risk of breakages to the machinery.

Feed Rollers Licking.—This is sometimes a troublesome matter, and in such cases it is a good thing to give the feed roller, or rollers, as the case may be, a good rubbing with blacklead or French chalk. In extreme cases it is sometimes advisable to set the first beater grate-bar closer to the feed to remedy the evil.

Cleaning.—At intervals the calender rollers should be taken out, and all the front of the machine given a thorough cleaning, this being conducive to the production of good laps.

Uneven Laps.—In cases of uneven laps everything about the piano motion should receive the strictest attention. The bowls should be taken out of the bowl box at intervals, well-cleaned and black-leaded, not oiled, as some think. Great care should be taken to correct insertion again and freedom of working in the bowl box, any worn studs or bowls being renewed. The levers connecting the pendants to the fork of the cone belt should be in good order, and the cone belt itself should always be carefully watched. Occasionally the feed rollers have been made so weak as to spring in the middle, thus allowing the cotton to be pulled through in lumps, with consequent irregularities later on. The same thing is likely to occur if the feed rollers are too lightly weighted. Loose doors about the machine and crevices in the framework should be guarded against, as they tend to divert the current of air from its proper course, and this must tend in the direction of irregular lap making. Dirty passages for the exit of the air must be avoided. Care must be taken not to have the forks for the cone belt too wide, or uneven laps will result. The same thing may be expected to follow if the pendants and bowls are slack in the bowl box. Also see that the adjusting screw at the end of the bowl box is carefully regulated.

Bad Selvages.—Great attention should be paid to the lining and proper recessing of the ends of the cages, or thin

edges may be expected in the laps, resulting in a bad selvage in the web at the front of the card, and occasionally inducing the serious evil of 'plucking' at the back of the card between the feed roller and taker-in. To produce good edges some machinists have recently adopted the principle of narrowing, by which the lap at the front is made slightly narrower than the laps in the creel, the same thing being carried out in the card also.

Damaging the Fibres.—The fibres may be damaged by :

(*a*) Allowing the beater to make too many revolutions ;

(*b*) Setting the beater too close to the feed rollers ;

(*c*) Setting the beater too near to the grate-bars ; or,

(*d*) Having the beater blades badly worn.

In the last case the cotton will not always be struck clear from the feed, and such cotton as may be momentarily suspended from the feed will be cut and nipped by overbeating. When the blades are worn they should at once be made right.

Dirty Laps.—They may be the result of the beater revolving too slowly, or of allowing the leaf and dirt bars and chambers to get too full. If the fan be creating too strong a current, some of the dirt and leaf will be carried forward instead of its being allowed to fall out. On the other hand, if the air current be too weak it will allow good cotton to drop out. It is clear that what is required is to have the current of air just sufficiently strong to overcome the weight of the fibres, but not that of the impurities. Practically the same causes which cut the fibre will tend to nep it. If the grate bars are too far apart good cotton will fall out.

Lap Roller.—The vertical racks should be kept well cleaned and oiled, and the brake on the rack pinion shaft should be kept in good condition, and firmly pressing against

the brake pulley, in order to ensure good and firmly-built laps
A sufficient amount of weight should be maintained on the
friction brake lever. Care should be exercised not to have one
side of the lap roller more firmly weighted than the other side,
or there will be a tendency to have a soft thick edge at the
more lightly-weighted end.

Some Notes on the Carding Engine. Flocks.—
If slight spaces exist between the cylinder and the sides of the
card there is a probability that flocks will result. This will
also happen if the cylinder has been clothed up to the very
edge. Flocks, too, are frequently caused by accumulations
beneath the doffer of fly, from which the doffer keeps with-
drawing small portions and taking them along with the web.
It is possible, too, for slack filleting to cause the same evil.

Flat Strips.— If the top sharp edge of the front plate be
set a little further away from the cylinder it will cause the flat
strips to be a little heavier, owing to the cylinder having a better
chance of sending off the fly. If the front plate be set too far
away, it is probable that the flats will leave the cylinder in a
continuous web. Sometimes the flats will not strip clear, owing
to the wire being too hard and rough. Perhaps the most
common cause of dirty laps is having the stripping brush too
deep in the wire of the flats. This is a very common and very
serious evil. When a workman sees the flats dirty he naturally
sets the brush deeper, but this frequently causes the bristles to
rub against the foundation of the wire and embed the fibres
in the wire, with the effect of making matters worse instead of
better. When the strips are heavier at one end of the flats
than the other it may generally be taken that the front plate
is a little further away at the heavy end than at the light
end.

This same result may arise from a difference in the angle
of the wire. When the strip from one flat is different from the

strips of the others, it will generally be found to be due to a difference in the bevel of the flat or in the wire.

Cloudy Web.—This is generally the result of improper or insufficient stripping, grinding and setting. If these are not properly attended to we may expect to find raw and uncarded portions of cotton in the web. If the various carding organs get full of fly, or they are too far away from each other, or the points of the wire are not in good condition, it is certain to result more or less in cloudiness of web.

Web Hanging.—If the web hangs slack between the doffer and the calender rollers, the calenders may be slightly speeded. It is possible there may be something wrong with the gearing of the calenders, or the weight of the sliver may have been considerably altered, or the web may be improperly stripped by the doffer comb.

Web following Doffer.—This may be caused by—

(*a*) The doffer comb being too slow ;

(*b*) The weather affecting the web ;

(*c*) The comb being too far away from doffer ;

(*d*) Or, the wire being damaged.

Black-leading.—When a carding engine is first started, or when it is being reclothed, it is a good thing to black-lead the under casing, mote knives and feed part, to obviate any possible chance of the cotton sticking anywhere. The same may be done to the card sides and bends.

Choking of Taker-in.—This may be caused by the cross belt which drives the licker-in slipping, or the taker-in having the cotton fed to it too thickly. Formerly it was a most serious evil, because the feed rollers would keep delivering the cotton upon the taker-in until it got on the cylinder in considerable quantities, in some cases sufficient to break some of the flats. This has been remedied in modern cards by driving the doffer from the licker-in, and, as the doffer drives the feed roller, it

follows that when the licker-in chokes and stops, both the feed and delivery stop at the same time.

Nep.—Quite a number of circumstances about a card may arise to cause nep. For instance, careless or insufficient stripping, grinding and setting, or overloading the wire by feeding too thickly.

Hooking of the Wire.—This may be caused by having the grinding roller too heavy on. It is better to grind lightly and often, than heavily and at long intervals.

Choking of the Wire.—Sometimes the wire near the sides of the cylinder does not strip clean. It may be because the clothing has swollen slightly at those points. Often, however, it is the fault of the wire stripping brush, which may have been damaged, or it may be due to soft wires at the ends. Occasionally the stripping brush may get slightly overlapping the sides of the card, in which case the brush may be held off the cylinder wire by the card sides.

Occasionally, too, defects in the cylinder wire will reflect upon the taker-in in the following manner :—The cylinder wire at certain places does not strip clean, and becomes choked up with short fibres. It then refuses to take any more cotton from the licker-in at that point, when the latter, therefore, naturally has a rope-like accumulation of cotton formed round it.

Whiting for Laps.—Sometimes certain classes of cotton cling to the wire of the cylinder and flats so tenaciously as to preclude clean stripping. In some cases an effective remedy has been obtained in sprinkling the lap behind the card with thoroughly dried and finely powdered whiting or French chalk.

Mote Knives.—These should be of the correct angle and accurately set to assist the taker-in in thoroughly cleaning the cotton from the heavier impurities at the back of the card. As a rule the mote knives may be set closer, and the undercasings

further away, to make more waste. It is very important that the undercasings should be concentric with the cylinder.

Slow-motion Grinding.—This does not now meet with anything like the general acceptance that it did a few years ago. Many practical men will have nothing whatever to do with it.

Testing Flat Strips.—Run the cards which are to be compared for a given length of time—say, two hours. Then carefully weigh the strips from each card. This will furnish a reliable and satisfactory test.

Drafts.—When there is any doubt as to whether a card has correct drafts, it is advisable to separately test the draft between the following :

(*a*) Lap roller and feed roller ;

(*b*) Feed roller and doffer ;

(*c*) Doffer and calender rollers ;

(*d*) Calender roller and coiler-top rollers.

Some Notes on Draw Frames. Leather Rollers.—Among the many things claiming special attention in cotton-spinning, none is more important than the leather roller of the draw frame. Loose boss rollers on these frames have become almost universal within recent times—at any rate, for front rollers. There can be no doubt that they are much better than fast rollers.

Recently one firm of machinists (Messrs. Dobson and Barlow, Bolton) has adopted loose ends to these rollers, with very beneficial results. The rollers should be kept in good condition, and well varnished at suitable intervals.

Stop Motion.—By far this is the most important mechanical part of draw frames, and every care should be taken to keep it in perfect working order. The spoons should be well balanced, and the parts correctly adjusted, in order to secure an uniform front sliver.

Draft.—The draft of the drawing frame is usually equal to the number of slivers doubled together. It is thought by some to be conducive to good work on these machines if the draft be rather less than the doublings : say, $5\frac{3}{4}$ with 6 ends up, and $7\frac{1}{2}$ with 8 ends up.

Three or Four Heads.—Cotton passed through too many heads of drawing, or 'overdrawn,' as it is termed, is likely to have the nature taken out of it, and to make much waste. The fibres also may be strained, resulting in weak yarn.

Clearer Waste.—Every attention should be paid to the clearers, or 'flats,' of the top rollers, in order to prevent accumulations of fly from passing from them along with the good cotton. In this connection the patent clearers are useful. As is well known, this flat waste is an evil which at times gives considerable trouble in the mill.

Some Notes on the Sliver Lap Machine.—Cutting of slivers and making of thin places in the lap are often due to carelessness in cleaning, oiling, and varnishing of the leather rollers of the sliver lap machine. Care, too, should be taken to have all the parts of the spoon stop motion in good condition, in order to avoid uneven laps. The vertical racks and the brake should be well attended to, and the latter kept firmly pressing against the brake pulley, in order to ensure good work.

Ribbon Lap Machine.—Remarks made on the sliver lap machine apply with equal force in this. The following should be kept perfectly clean and smooth : (*a*) front table, (*b*) curved front guide plates, (*c*) and the various calender rollers. The cotton laps are of a very open and thin character as they pass round the curved plates, and the slightest resistance is liable to cause the cotton to be diverted, with consequent waste. It is a common plan to make the front laps at this machine about one

inch wider than those put in the creel, in order to allow for the spreading which takes place.

For the same reason there are adjustable guides for the cotton, which are placed at the back of the rollers and between the rollers, as well as at several points on the front table. By means of these guides the spreading can be limited and controlled. Wash-leather is a good thing to use in cleaning the front curved plates, and the calender rollers may be dusted with a little French chalk, to prevent the cotton sticking to them. It would doubtless add to the value of this machine if a front stop motion could be adopted, as in the case of the draw frame, so that when a lap or laps failed at the front the machine would stop automatically.

Some Notes on the Comber Machine. Springs.— The springs and weights for the top feed rollers and the leather detaching rollers should be kept at a uniform tension. This will often ensure correct action of the working parts of the machine.

Waste.—Great care should be exercised here, and careful watching is needed in order to keep as near as possible to the standard required. The weight of good cotton and the weight of waste made for a certain number of nips should be carefully ascertained, each weighed separately, and then the two weights should be added together. It will then be an easy matter to calculate the proportion of waste, or the percentage of waste made. A greater percentage of waste follows when—

(*a*) The nippers are made to close later ;
(*b*) By the clutch box closing later ;
(*c*) By having greater angle on the top combs ;
(*d*) By closer setting of the various parts.

Leather Detaching Rollers.—Four important precautions must be borne in mind with regard to these rollers : (*a*) cleaning, (*b*) oiling, (*c*) varnishing, (*d*) re-covering at proper

intervals. Failure to observe these will result in unsatisfactory work, and some of the good cotton will be taken round by the cylinder instead of going on its proper course.

Setting.—On a comber it is of primary importance that the various working parts be accurately adjusted to each other as regards distance apart and timing.

The latter is specially important in all machines working intermittently, as the comber, mule, and loom.

Oiling.—This is important, and the screws, so numerous in a comber, should be carefully watched and kept tight.

Hand of Comber.—To determine the hand of a comber, stand in front of the long sliver table and note whether the driving pulleys are on the *left* hand or *right* hand.

Duplex Comber.—This will easily run 120 nips per minute. The double nip in some machines is obtained by making the cam shaft go twice round to one of the cylinder, and in others it is obtained by having double cams on the cam shaft.

Weights, &c.—The top feed rollers and detaching rollers must be properly and uniformly weighed if good work is required. Proper seating of the loose ends or bearings of the detaching rollers should be secured. The flutings on the rollers should not be worn ; this is fatal to good combing. Poor work may be expected also if the parts are not working parallel.

Cylinder Bearings.—Occasionally these become worn by long working, particularly when the combers are on a stone or flagged floor. Periodic inspection is desirable, and this will ensure defects in bearings being left unattended to.

Comb Teeth.—These are very liable to get broken, both on the top comb and cylinder. Broken combs should not be allowed to remain long. If they get hooked from some cause or other, a small pair of pliers or other instrument may be used to straighten them. Extremes of temperature are very

undesirable, and injure the combs as well as the wire on the card, by having moisture deposited, with consequent rusting.

Roller Laps.—Thick lap accumulations on the feed rollers should not be allowed, otherwise broken needles may be expected, and, in some cases, derangement of the machine.

Some Notes on Bobbin and Fly Frames. Regularity of Taper or Cone.—It is by no means uncommon to see the tapers on the one bobbin not alike, the angle of the taper in the one being either greater or smaller than in the other. The chief remedy for this is to have the ' hanger bar,' or ' tapering rod,' horizontal and absolutely in the centre of the lift.

Waste.—At short intervals the flyers and flats should have any superfluous cotton waste removed from them, in order to prevent small pieces of this passing on the bobbins.

Long Piecings.—One of the most common and fruitful causes of bad yarn is the practice of making long or very hard piecings of roving either at the back or front bobbins.

Passage of Cotton.—Care should be taken to maintain a uniform system of wrapping rovings round the presser finger, whether the rule be to have the rovings conducted once, twice, or thrice round. Otherwise there will be a tendency to make hard and soft bobbins, and to have some rovings stretched more than others. If the cotton is conducted the wrong way round the flyer tops, the proper twist will not pass into the cotton effectively, and the rovings will have no strength in them.

Alteration in the Cone of Bobbin.—The spur wheel that gears into the 'round rack,' or 'hanger bar,' may be changed to a larger, in order to put more cone in the bobbins, and *vice versa*. The greater the amount of cone the less tendency there will be for the bobbins to run under and over, but the bobbins will hold less cotton.

Running ' over and under' of the Bobbins.—This is one of the most prevalent evils met with. It is well known that bobbins of this kind are continually breaking in the creel of the next machine, thus making waste and bad work. To remedy this, the cone of the bobbin may be increased ; the small strike wheel, and the wheels from the reversing bevels to the lifter, should be carefully examined, to see that none of them are loose on their shafts or studs. Any such slackness is sure to produce running over and under, owing to the wheels first turning one way and then the other. The same result will follow if there is too much back-lash in these wheels, due to being too shallow-geared. All these defects militate against the lifter's direction of motion being promptly reversed, and so cause a hesitancy in the vertical movement of the bobbins just at the changing. Loading of the lifter by the collars binding, or by the ' hanger bar' binding also, induces running ' over and under.'

Regulating the Length of Lift.—Slacken the jack screws in the top cradle of the ' building motion,' or ' box of tricks.' Mark the two extremities of the bobbin with chalk at the points to which it is desired to take the cotton. Carefully run the lifter until the eye of the presser is exactly over the chalk mark at one end of the bobbin. Then set down one of the jack screws until it releases the ' catch' or ' detent lever,' which is then holding the bottom cradle. Afterwards run the lifter to the other extremity of the bobbin, and repeat the operation for that side of the motion.

Twist Wheel.—This is the most important wheel on the frame, and a change in its size would practically affect every motion on the frame except the spindles, which are independent of every other motion on the frame.

Tension of the Ends.—This is regulated chiefly by the cone drums. The tension of the ends for the first lift on the

empty bobbins should be regulated by the wheel that drives the sun wheel (or its equivalent in the new differential motion) (*see* figs. 102 and 103). After the first lift it should be regulated by the ratchet wheel, a larger wheel making the ends tighter. The ratchet wheel catches should be set half-tooth with each other, or there will be a tendency to have the ends slack at one change and tight at the other. If the cover be of incorrect curvature, it will be impossible to get absolutely correct winding all through the set.

From Flyer to Bobbin Leading.—In changing from flyer to bobbin leading, the two things to be attended to are—

1. Alteration of the wheels to make sun wheel go round in reverse way, so as to increase the speed of the bobbins instead of decreasing it.

2. Obtain fresh flyers with the pressers going in advance of the leg instead of hanging behind it.

Closeness of Coils.—The closer the coils of roving are laid together the harder will be the bobbins, but overlapping must be carefully avoided.

Some Notes on the Mule. Twist Wheel and Speed, or Back Change, Wheel.—On most American cotton mules there is no twist wheel proper, and the speed wheel therefore regulates the twist by quickening or slowering the speed of the carriage, while the speed of the spindles remains the same.

On most Egyptian cotton mules there is a twist wheel driven by a worm from the rim shaft in addition to the speed wheel. In such cases the twist wheel determines the total amount of twist per stretch to be put into the yarn, while the speed wheel regulates the proportion of the total that shall be put in during the making of the stretch and the proportion to be put in while the carriage is on the holding-out catch.

To Improve the Backing Off.—When the friction is in, care must always be taken to see that nothing is paralysing any

of the force of the 'backing-off' spring. The friction may be set a little deeper in gear. The backing-off spring may be tightened or renewed. The friction may be 'skimmed,' or re-covered. The various levers belonging to the backing off should be correctly centred.

To make the Bottom Cone of Cop Longer or Shorter. —More of the front copping plate must be put at work, although this will make the bottom half of the cop thicker than previously. The opposite course may be pursued to make the bottom cone shorter, or to make the bottom half of the cop thinner.

To alter the Locking of the Fallers.—The loose front incline may be raised up to lock more deeply, and it may have more incline put in it to lock the fallers nearer to the apex of the cop chase. These alterations will usually be effected by suitably adjusting the loose inclined plate. It will generally be found that locking deeper will make the cops 'ready' better.

To Lengthen or Shorten Cop Chase.—This may usually be best effected by altering the vertical screw which is now invariably placed at the front end of a copping rail.

Back Copping Plate.—By putting more or less of this plate to work the length of the cop bit may be considerably varied without much affecting the chase of the cop after the 'thickness' has been attained. More of this plate at work shortens the cop bit, and *vice versa*.

Short Copping Rails.—With these rails it must be specially noted that the back plate has much more to do with the 'squareness' of the cop than it has with long copping rails, on account of its closer proximity to the ridge of the rail.

Crossing Threads.—As a rule when cops are intended to be put in a creel for doubling purposes it is better to have plenty of crossing thread, to prevent the cops from overrunning themselves.

Unlocking of the Fallers.—If this takes place too late the threads will be cut and strained, while if it takes place too early the threads will be filled with snarls.

To make Harder Cops.—The most common and ready method of doing this is to put more weight on the counter-faller. Making a longer chase on the cops will tend to make them harder, as will keeping the ends tight by turning the quadrant nut back, or by having plenty of nose-peg on. Tightening the backing-off chain will also harden the cops. If any of these remedies be carried too far, breaking of ends will result.

To take Snarls Out.—Adopt such of the following remedies as specially apply :—

1. Set on more keenly the anti-snarling motion, hastening motion, or nosing motion.
2. Turn the quadrant handle a little backwards.
3. Tighten the front scroll band or check band.
4. Put more 'gain of carriages' or more 'ratch.'
5. Have less bevel in the spindles ; or
6. Unlock fallers later.

To get Mule on Catch Better.—Have less 'strap-relieving' motion at work ; have less 'ratch' in ; make the changes later when the carriage gets out ; have less of the back shaft scroll inclines at work ; see that none of the front stops or other obstructions are hindering the carriage from getting out. If a mule does not get on the 'catch' properly it is probable it will not back off, owing to the 'backing-off friction' not being engaged with sufficient firmness, or because the 'winding click' prematurely engages with the winding wheel.

'Ratch' and 'Gain.'—On the ordinary type of mule spinning, low or medium numbers, there is never any 'ratch' put in, and there is no appliance on the mule for putting it in. In such cases there is often very little, if any, 'gain' put in. 'Gain   is obtained by having the surface speed of the carriage

x

slightly greater than the surface speed of the rollers during the outward movement. Ratch is only put in at the termination of the outward movement ; and is obtained by entirely, or almost entirely, stopping the rollers while the carriage moves a little further outwards.

Winding Catch Slipping.—This may be due to the winding wheel being worn ; or the catch itself being worn, or being at a wrong angle ; or to the winding spring being too weak or worn on the leather, or not being bent properly. Practically the same remarks apply to the backing-off catch slipping.

Bad Spinning.--This may be due to : (1) the cotton not being good enough, (2) the bobbins at the roving frame being badly shaped, (3) ratched, (4) to badly covered leather rollers, (5) the various motions being too keen, (6) to the ' ratch ' and ' gain,' (7) the weighting of the fallers being excessive, (8) to the ' spindle bevel ' being too small, (9) to the mule wanting re-setting, (10) to the mule being out of square, (11) to bad copping, (12) to irregular roving, (13) to the iron rollers being worn, (14) to very dry and frosty weather, (15) to the mule being over-speeded as to spindles, or (16) to the iron and leather drawing rollers being set at wrong distances apart.

Quadrant.—This regulates the winding in such a manner as to compensate (by the aid of the governing motion) for the ever-increasing diameter of the cops from the bare spindle to the maximum thickness required, and also to largely make compensation for the conical shape of the cop chase. A larger quadrant pinion gives a less sum total of winding during any one run-in of the carriage, because it drives the quadrant forward more.

Carriage Springing Out.—This may be caused by having the down belt or belts too tight, or by having too much hastening motion on, or by having a very slack rim band.

Frictions.—These should be taken out at intervals and

scraped or 'skimmed.' If very bad it is best to have fresh leathers put on. Otherwise we may have defective operations of the mule in its most important parts, viz. : those connected with the ' changes.'

Some Notes on Ring Spinning. Drawing Rollers. —To ensure good work, these must be kept very clean and well lubricated. Especial care should be taken to prevent oil from getting on the leathers of the top rollers.

Guide Boards.—These should be kept well wiped, and free from waste, as also should the creels, skewers, stirrups, stands, and clearer boards.

Travellers and Traveller Clearers.—Constant care should be exercised to keep the travellers free from accumulations of fly, and in this connection the clearers should be set about $\frac{1}{100}$th of an inch away from the travellers. The counts of traveller must be very carefully graded to suit the counts and the cotton.

Spindle Bands.—These should be of good quality, and every attention should be bestowed upon them, to ensure regularity and firmness of tension. These conditions on a ring-frame very materially affect the winding and the quality of work obtained.

Heart Motion.—The lifting rods should work easily and certainly, and in this connection care should be taken not to have the heart cam worn or loose, as this will give a back lash.

Roller Traverse.—This should be kept in good condition, to prevent channelling of the rollers and uneven drawing.

Rings.—Perfect concentricity of the rings with the spindles is one of the most essential conditions to satisfactory working, and to maintain this all through the lift the traverse must be absolutely vertical, and the concentricity must be tested at all points of the traverse.

CHAPTER XX

Humidity.—If a shallow vessel containing a little water be placed in a warm room the water will quickly evaporate and the vessel will be left empty.

The water by a natural process, viz. evaporation, has been changed from liquid to vapour.

The capacity of the atmosphere to absorb water, or really hold it up in this invisible condition varies according, to temperature.

Thus at freezing point a cubic foot of air will retain 2·13 grains of aqueous vapour, while at 100° F. it will hold in suspension no less than 19·84 grains of aqueous vapour, or practically ten times as much. A cubic foot at 100° F. will hold no more than the amount stated, and at this temperature the air is said to be *saturated*. It also may be said to have its maximum vapour tension or pressure.

The point at which a volume of air becomes unable to sustain moisture is known as *dew point*; in other words, if a lowering of the temperature of a volume of air or space takes place then water-vapour condensation begins.

The expressions '*dry air*' and '*moist air*' are only relative terms, and simply express the proportion of aqueous vapour present at the given temperature compared with that which the same volume of air could hold. It will perhaps be interesting to show how the dew point may be readily found at any time. For this purpose what is known as Daniell's Hygrometer is used (*see* fig. 139).

This consists of a tube bent at right angles twice, having a bulb at each end. The bulb at A is about two-thirds full of ether, and in this ether a very sensitive thermometer is placed. The other bulb contains only the vapour of ether, as does also the tube connecting the two bulbs. Before closing this tube the ether was boiled, so that there is nothing inside except ether and the vapour of ether.

Round the bulb at B is placed a little muslin, as shown in the illustration. Now, to find the dew point, we drop ether on to the muslin round the bulb at B. As this rapidly evaporates it condenses some of the vapour of ether which is inside into the bulb B. To compensate for this condensed vapour more ether is vapourised at A, with a result of a lowering of the temperature there and a consequent falling of the thermometer placed inside.
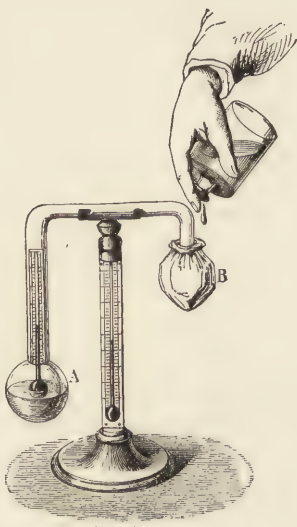
FIG. 139.—DANIEL'S HYGROMETER.

This dropping of ether on B is continued for some little time, until the temperature is so lowered at A that the air about this bulb is affected, and dew begins to be deposited on A.

The temperature inside the bulb is then noted, and this is the temperature at which dew would be deposited if the air outside were reduced similarly. In other words, the inside reading is the *dew point* for the outside air.

As there is always some little difficulty in deciding the exact moment when the dew appears, it is usual to watch the dew disappear and to note the temperature of the inside

thermometer when this takes place, and then to take the average of the two readings.

The actual amount of vapour present in a given volume of air at any time is the *absolute humidity*. The actual amount that could be present in the same volume under precisely the same conditions of pressure and temperature is the *maximum humidity*. Now the ratio of the absolute humidity to the maximum humidity is the *relative humidity*, and this is what we are most concerned with in dealing with humidity as it applies to cotton spinning. For example, suppose the air of a mule room contains out of a possible maximum of 100 say 60, this means that it has a relative humidity of 60 per cent.

How to find Humidity.—The relative humidity can be found readily when we know—

(*a*) The dew point ;

(*b*) The temperature of the air ;

(*c*) Tables which give the vapour tension or saturation pressure of the air for different temperatures.

Temperatures	Tensions in Millimètres	Temperatures	Tensions in Millimètres
Centigrade		Centigrade	
0°	4·6	17°	14·421
1°	4·94	18°	15·357
2°	5·302	19°	16·346
3°	5·687	20°	17·391
4°	6·097	21°	18·495
5°	6·534	22°	19·659
6°	6·998	23°	20·888
7°	7·492	24°	22·184
8°	8·017	25°	23·550
9°	8·574	26°	24·998
10°	9·165	27°	26·505
11°	9·792	28°	28·101
12°	10·457	29°	29·782
13°	11·062	30°	31·548
14°	11·906	31°	33·405
15°	12·699	32°	35·359
16°	13·635	33°	37·410

To make clear this point, the following example may be worked :—'You are required to find the relative humidity of a spinning room when the temperature inside is 17° C. and the dew point is 12° C.'

M. Regnault gives the tension of aqueous vapour for different temperatures as in the table on page 310.

The table shows then that the pressure of vapour at 17° C. (the temperature of the room) is 14·421 m.m. of mercury, and at 12° C. it is 10·457. We see then that the air, had it been saturated at 17° C., or 100 of a humidity, would have had a vapour pressure of 14·421, but at the temperature it was when the experiment took place it had only a pressure vapour of 10·457, because its dew point was 12° C. Now by a proportion we may work out the relative humidity. If the vapour pressure 14·421 is represented by 100 humidity, what will be represented by 10·457 ?

$$14\cdot421 : 10\cdot457 :: 100 : x = 72 \text{ per cent. humidity.}$$

This method of calculating the relative humidity is, however, a very long one, and is not likely to become popular, as it requires in every case a distinct experiment, viz. finding dew point, and obtaining vapour tensions of temperature of room and of dew-point.

Another way is to use what is called 'the Wet and Dry Bulb Hygrometer,' or 'Hygrophant,' as it has been recently called.

This instrument (shown in fig. 140) is made by Casartelli, of Manchester, and consists of—

1. A suitable frame ;
2. Two thermometers, one dry, the other wet ;
3. Table mounted on cylinder and so placed that the relative humidity can be read instantly.

Now let us see how this works. The dry bulb denotes the
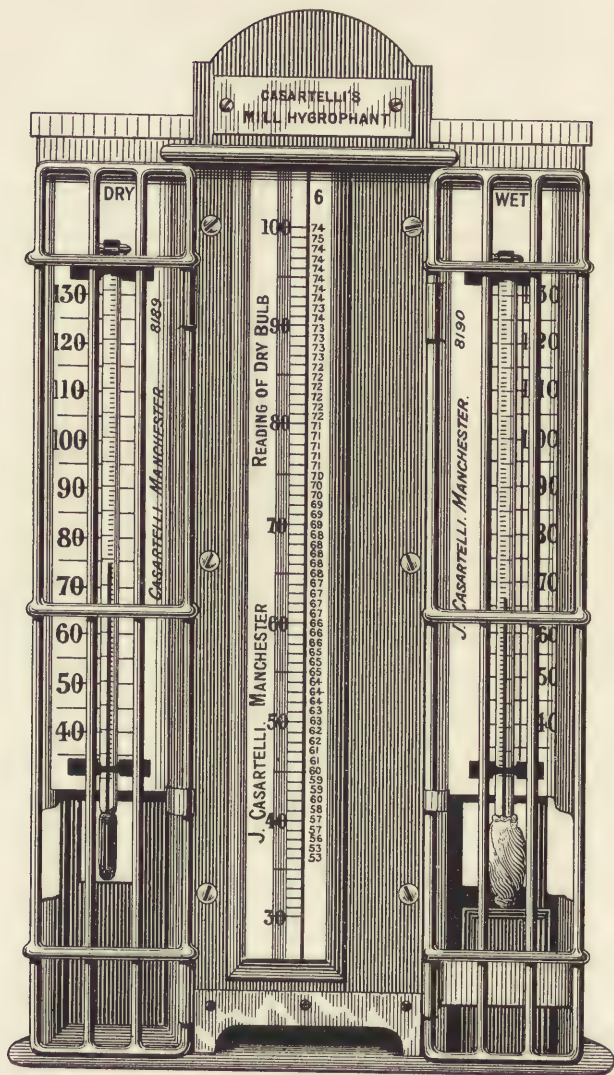
FIG. 140.—CASARTELLI'S MILL HYGROPHANT.

temperature of the air. The wet bulb is surrounded by muslin and connected by strands of cotton with a vessel of water. This must have a narrow neck, to prevent evaporation of the water inside the vessel. It is desirable to have the water conducted with as little loss as possible to the bulb, as it is at the bulb we want evaporation.

We have already shown that evaporation varies with the temperature ; but another important fact must be stated, that when evaporation is going on heat is expended. This can be readily proved by putting a few drops of ether on the palm of the hand. Instantly we feel the hand cold, because heat is abstracted from the hand in order to evaporate the ether ; just in the same way water is evaporating in close proximity to the bulb, and the heat is taken from this bulb in consequence, and we see when the instrument is working properly in ordinary temperatures that it records a lower temperature than the dry bulb. It is clear, too, that the greater evaporation there is going on the greater the difference which will be recorded. When the two readings closely approximate, then little evaporation is going on.

Let us repeat that when the air refuses to sustain any more vapour it is saturated and records a maximum of 100 per cent. humidity. The vapour it has in it at any given temperature compared with what it could have in it at that temperature is the *relative humidity*, and this is what Casartelli's instrument will find for us quickly.

The reading of the percentages mounted on the cylinder is simplicity itself, and it is to be noted that the table is thoroughly reliable, having been compiled carefully from Professor Glaisher's hygrometrical tables. We give the maker's method of how records may be taken by this instrument :

' To ascertain the percentage of humidity at any temperature it is only necessary to take the readings of the dry and wet bulb

thermometers and note the number of degrees of difference between the two readings.

'The figure corresponding to this difference is then brought to the top on the revolving cylinder, and the percentage of humidity at any reading of the dry bulb from 30° to 100° F. is read off by means of the graduated scale at the side.'

We give here just a portion of the larger table which is pasted on to the cylinder referred to, and which conveys a good idea of the working of the instrument.

TABLE OF DIFFERENCES OF WET AND DRY BULBS AND THE
RELATIVE HUMIDITY IMPLIED

Tempera-ture as shown by dry bulb	Differences between Wet and Dry Bulbs											
	1	2	3	4	5	6	7	8	9	10	11	12
	Percentage Humidity											
86	95	90	85	80	76	72	68	64	61	58	55	52
85	95	90	85	80	76	72	68	64	61	58	55	52
84	95	90	85	80	76	72	68	64	60	57	54	51
83	95	90	85	80	76	72	68	64	60	57	54	51
82	95	90	85	80	76	72	68	64	60	57	54	51
81	95	90	85	80	76	72	68	64	60	56	53	50
80	95	90	85	80	75	71	67	63	59	56	53	50
79	95	90	85	80	75	71	67	63	59	56	53	50
78	94	89	84	79	75	71	67	63	59	56	53	50
77	94	89	84	79	75	71	67	63	59	56	53	50
76	94	89	84	79	75	71	67	63	59	55	52	49
75	94	89	84	79	74	70	66	62	58	55	52	49
74	94	89	84	79	74	70	66	62	58	55	52	48
73	94	89	84	79	74	70	66	62	58	54	51	48
72	94	89	84	79	74	69	65	61	57	54	51	48
71	94	88	83	78	73	69	65	61	57	53	50	47
70	94	88	83	78	73	69	65	61	57	53	50	47
69	94	88	83	78	73	68	64	60	56	53	50	47
68	94	88	83	78	73	68	64	60	56	52	49	46
67	94	88	83	78	73	68	64	60	56	52	49	46
66	94	88	83	78	73	68	64	60	56	52	48	45
65	94	88	83	78	73	68	63	59	55	51	48	45
64	94	88	82	77	72	67	63	59	55	51	48	45

Another very good form of hygrophant has recently been

put upon the market by Dowson, Taylor and Co., of Man-
chester, in which the wet bulb is connected with a large well of
water of a hooked form with a small hole (*see* fig. 140*a*).   This
allows uniform action, and ensures a constant supply of water
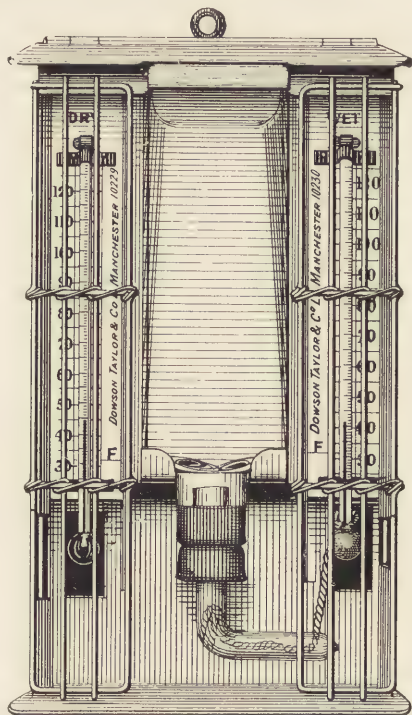
FIG. 140*a*.—DOWSON, TAYLOR AND CO.'S HYGROPHANT.

for a good length of time.   The differences are noted as before
but instead of a cylinder giving readings of humidity, a book of
tables by Glaisher is supplied.

Various Methods of Humidifying.—Two classes of
agents for humidifying are now in use, viz.—

(*a*) Artificial ; | (*b*) Natural.

Among the former we may place all those appliances which by mechanical means force water into the atmosphere in a finely subdivided condition.

By the kindness of Messrs. Dowson and Taylor, of Manchester, we are enabled to describe the construction and action of one of the latest forms of moisture-producing apparatus (*see* fig. 141).
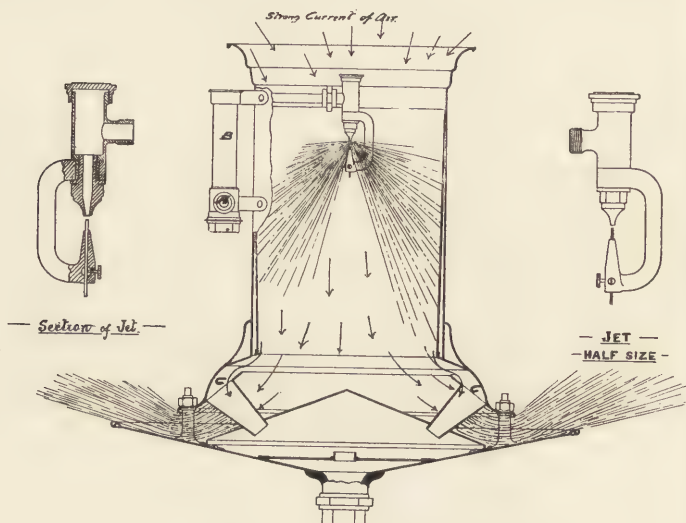
FIG. 141.— SECTION OF 'VORTEX' HUMIDIFYING APPARATUS.

It is claimed for this machine that special attendance is not necessary ; that moisture is uniformly distributed ; that frictional electricity is prevented or rendered latent ; that the water is thoroughly vapourised when the temperature is right ; and that a coarse discharge is impossible. The working of this appliance will readily be understood by referring to the figure. The feed pipe, with a pressure generally of 135 lbs. per square inch, is connected to the humidifier at A (fig. 141), and the water is

filtered before it gets to the jet by passing through a strainer inside the strainer box B. The water then passes through the orifice of the jet, and striking against the pin, which is about $\frac{1}{16}$ inch away, is split up into very finely divided particles of moisture, and forms a hollow cone of water. This water issuing from the jet at the above-named pressures induces a very strong current of air through the top of the machine, which absorbs a large quantity of the finely divided water coming from the jet, and also by its force carries the fine moisture along with it, and this issuing from the base of the machine is readily absorbed by the moisture. All not absorbed in this manner passes down the side of the cylinder of the machine into the cavity C C, and thence to the base of the machine, back to the tank, without allowing any large drops of water to cross the strong current of air produced. The heavy moisture which drops on to the cone at the bottom of the machine adheres to it and flows back into the tank, to be used over again.

There can be no doubt that this class of instrument effects what is desired quickly, but considerable opposition has been experienced in some districts to the introduction of this method of humidifying. On the Continent they are coming into general use, and from France, Germany, Russia, Austria and other countries very strong testimonials in their favour have been received. We show in section (fig 142) and plan how such an installation may be fixed and how foul air may be dispelled and fresh air supplied.

It is the opinion of some who have had much experience that the best of these appliances do not attain their object so well as do the simplest and most natural methods.

Variously shaped troughs are used in many mills in which water either cold or tepid is exposed. This, by evaporation, is allowed to pass into the room. In order to accelerate evaporation the troughs containing the water are run in some cases
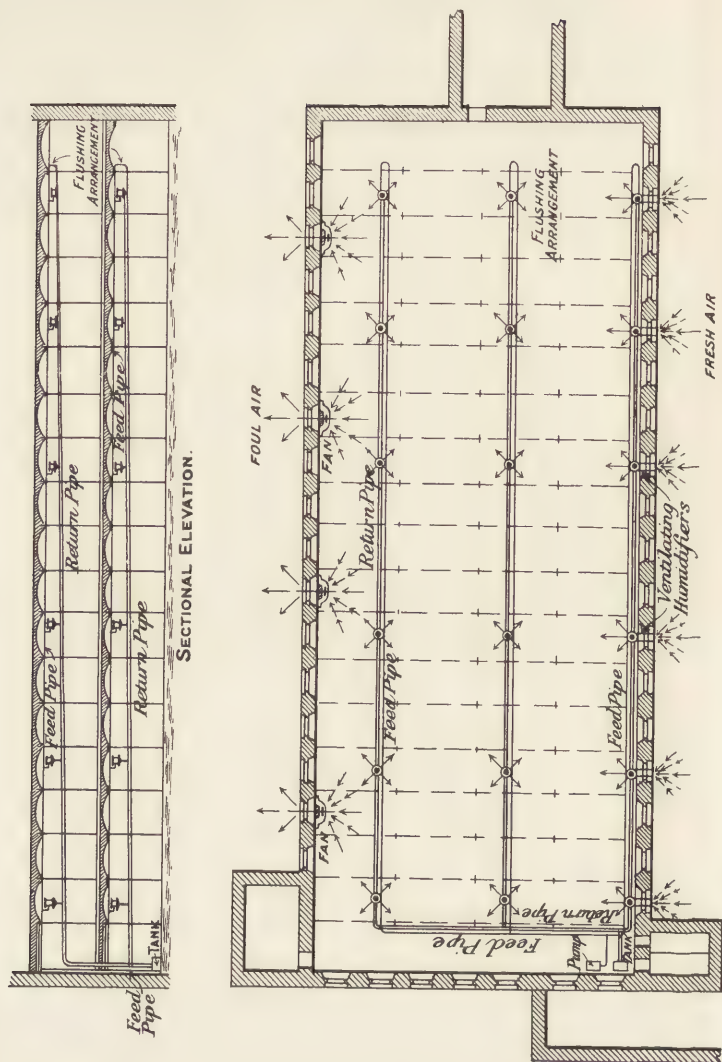
Fig. 142.—Plan and Elevation showing Humidifying Installation.

immediately over the steam pipes, the heat from which rapidly helps in the conversion of water to vapour.

The one great object sought in arranging these waterways is to get the greatest surface evaporation possible. In section the troughs are semicircular, v-shaped rectangular or u-shaped and stepped v. Another method, and one which is practised largely in some places, is to water the floors by means of an ordinary watering-can. This method has some objections, but there can be no doubt that it approaches most nearly to the perfect evaporation of water.

The following experiments may be of interest :—

On February 17, 1897, the relative humidity of the room shown in the frontispiece of this work was taken.

Dry bulb registered 68 ; wet bulb registered 57 ; difference was 11.

On reading under Column eleven for a temperature of 68, it was found that the relative humidity was 49.

One ordinary bucket of water was uniformly sprinkled over the floor, and in 20 minutes the readings registered : dry, 68 ; wet, 58 ; difference, 10 ; relative humidity, 52 per cent.

Six buckets were now added, and the room was left for two hours. At the end of this time, 2.10 P.M., the readings came out : dry, 69° F. ; wet, 62° F. ; difference, 7 ; relative humidity, 64 per cent.

There is no doubt whatever, as shown by this experiment, that the humidity of a room can be raised or lowered at will.

On February 18, at 9.15 A.M., the dry registered 65° F. ; the wet, 55° F. ; difference, 10 ; relative humidity, 51 per cent. ; this showing a fall of 13 per cent. on the previous day's record.

On February 19, at 2 P.M., the following results were obtained : dry, 67° F. ; wet, 59° F. ; difference, 8 ; relative humidity, 60 per cent.

This rise from the previous day is explained by the fact

that the relative humidity outside rose considerably from the preceding day, and was no less on the last day named than 86 per cent. The thermometers used in these tests were standardised and tested at Kew Observatory.

Cotton Cloth Factories Act, 1889.—The following is the special Abstract No. 48 which is affixed in the various factories and weaving sheds, relating to the humidifying of workshops and factories :—

' (1) The amount of moisture in the atmosphere of a cotton cloth factory shall not at any time be in excess of such amount as is represented by the number of grains per cubic foot of air shown in Column I., Schedule A (*see* next page), opposite to such figure in Column II. as represents the temperature existing in such cotton cloth factory at such time :

' Provided that in a cotton cloth factory the temperature shall not at any time be artificially raised above 70 degrees, except as may be necessary in the process of giving humidity to the atmosphere and according to the table in the said Schedule A.

' (2) The fact that the wet bulb thermometer in such factory gives a higher reading than the figure in Column III. of Schedule A opposite to such figure in Column II. as represents the temperature existing in such factory, shall be evidence that the amount of moisture in the atmosphere exceeds the limit in the preceding sub-section.

' For above purposes there shall be provided and kept in correct working order in every cotton cloth factory two sets of standardised wet and dry bulb thermometers.

' 1. One set to be fixed in centre, and the other at the side of factory, or (as may be directed by an Inspector) so as to be plainly visible to the operatives.

' 2. The occupier, manager or person for the time being in charge of the factory shall record the readings at the hours and in the form as required on Schedule B, given on page 323.

'SCHEDULE A (FORM 49)

' MAXIMUM LIMITS OF HUMIDITY OF THE ATMOSPHERE AT GIVEN TEMPERATURE

I	II	III	IV
Grains of Vapour per Cubic Foot of Air	Dry Bulb Thermometer Readings	Wet Bulb Thermometer Readings	Percentage of Humidity Saturation = 100
	Degrees Fahrenheit	Degrees Fahrenheit	
1·9	35	33	80
2·0	36	34	82
2·1	37	35	83
2·2	38	36	83
2·3	39	37	84
2·4	40	38	84
2·5	41	39	84
2·6	42	40	85
2·7	43	41	84
2·8	44	42	84
2·9	45	43	85
3·1	46	44	86
3·2	47	45	86
3·3	48	46	86
3·4	49	47	86
3·5	50	48	86
3·6	51	49	86
3·8	52	50	86
3·9	53	51	86
4·1	54	52	86
4·2	55	53	87
4·4	56	54	87
4·5	57	55	87
4·7	58	56	87
4·9	59	57	88
5·1	60	58	88
5·2	61	59	88
5·4	62	60	88
5·6	63	61	88
5·8	64	62	88
6·0	65	63	88
6·2	66	64	88
6·4	67	65	88
6·6	68	66	88
6·9	69	67	88
7·1	70	68	88
7·1	71	68·5	85·5
7·1	72	69	84

Y

'SCHEDULE A (FORM 49) *continued*

I	II	III	IV
Grains of Vapour per Cubic Foot of Air	Dry Bulb Thermometer Readings	Wet Bulb Thermometer Readings	Percentage of Humidity Saturation = 100
	Degrees Fahrenheit	Degrees Fahrenheit	
7·4	73	70	84
7·4	74	70·5	81·5
7·65	75	71·5	81·5
7·7	76	72	79
8·0	77	73	79
8·0	78	73·5	77
8·25	79	74·5	77·5
8·55	80	75·5	77·5
8·6	81	76	76
8·65	82	76·5	74
8·85	83	77·5	74
8·9	84	78	72
9·2	85	79	72
9·5	86	80	72
9·55	87	80·5	71
9·9	88	81·5	71
10·25	89	82·5	71
10·3	90	83	69
10·35	91	83·5	68
10·7	92	84·5	68
11·0	93	85·5	68
11·1	94	86	66
11·5	95	87	66
11·8	96	88	66
11·9	97	88·5	65·5
12·0	98	89	64
12·3	99	90	64
12·7	100	91	64

' 3. This form shall be kept hung up near the thermometers, and forwarded at the end of each month to the Inspector of the district, and a copy kept at the factory.

' 4. A copy of Schedule A, framed and glazed, shall be kept hung up in a conspicuous position and near each set of thermometers.

'SCHEDULE B (FORM 50)

'FORM FOR RECORDING THE READINGS OF THE THERMOMETER

' Name of Occupier_____.

' Factory No._____,

' Number of operatives employed in it_____.

Date	Readings				Re-marks [1]	If no Artificial Humidity produced insert No Steam
	Between 10 and 11 A.M.		Between 3 and 4 P.M.			
	Dry Bulb Ther.	Wet Bulb Ther.	Dry Bulb Ther.	Wet Bulb Ther.		
Year Month Day	Degrees F.	Degrees F.	Degrees F.	Degrees F.		
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
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17						
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22						
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24						
25						
26						
27						
28						
29						
30						
31						

' [1] Fill in, *e.g.* : Too damp, Correct, &c.

'(Signed)

'A. B.,

' *Occupier* or *Manager*.'

Fig. 143 is very interesting as showing the difference between laps, one made on the lap machine in a very dry atmosphere and the other made in a very moist one. The laps are just as taken from the machine and photographed, and unmistakably show the effect which a moist air has upon the cotton
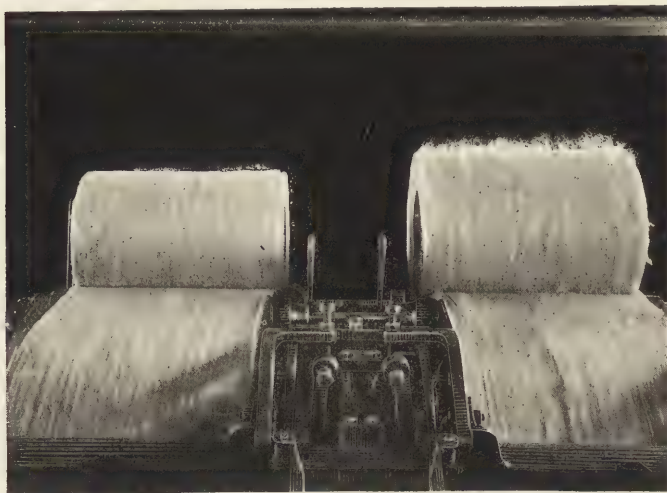
FIG. 143.—TWO LAPS : ONE MADE IN VERY DRY ATMOSPHERE ; THE OTHER MADE IN VERY MOIST ATMOSPHERE.

fibre in rendering it more workable and keeping down electrical effects, which so prominently manifest themselves when working in a dry and low-percentaged humid atmosphere. It should be stated that the photograph has suffered somewhat in the process, though it is sufficiently good to show a remarkable difference in the two laps.

CHAPTER XXI

Transmission of Power.—There are three principal systems by which power may be conveyed from the engine to the shafting which drives the machinery of a cotton mill : (*a*) wheel gearing ; (*b*) belt gearing ; and (*c*) rope driving.

Wheel Gearing is the oldest of the three systems, but is now rapidly becoming obsolete. It generally consists of a large spur segment wheel on crank shaft, driving a smaller wheel, or 'pinion,' on a second motion shaft. This shaft communicates the motion by means of bevel wheels to a vertical, or 'upright,' shaft in the gearing chamber, which in its turn also drives the shafting in the various rooms of the mill by wheels of similar form.

In calculating the speed and power transmitted by wheel gearing we must always take the pitch diameter as the effective diameter, and when the wheels are properly geared the pitch circles should touch or roll upon each other.

The following rule will give excellent results for calculating the H.P. (horse power) transmitted by cast-iron wheel gearing :—

(Pitch) ^{2} × breadth of tooth × speed in feet per minute ÷ 1,000 = H.P. safely transmitted.

Example.—A cast-iron spur wheel is $7'$ in diameter, and has 66 cogs of $4''$ pitch and $10''$ broad. The shaft on which the wheel is keyed runs 100 revolutions per minute. Find the H.P. which may be safely transmitted.

Circumference of pitch circle $=(3\frac{1}{7} \times 7)=22$ feet.

Speed of pitch circle in feet per minute $= (22 \times 100) = 2,200$ feet per minute.

$$\text{H.P.} = \frac{4 \times 4 \times 10 \times 2200}{1000} = 352 \text{ H.P.}$$

In applying the above rule to bevel wheels the 'mean,' or average pitch,' must be taken.

The maximum safe speed of cast-iron wheels is about 2,500 feet per minute, and steel wheels about 3,500 feet per minute.

Wheel gearing is the most expensive system, because of the necessary massive foundations of engine bed and thick gearing walls which support the shaftings in complicated wall boxes and fixings.

The chief advantage of this system of transmission is in the fact that slipping cannot possibly take place when wheel teeth are in gear, so we get an absolutely 'positive motion,' and *if* the teeth are correctly formed and properly geared, the wheels should work together uniformly with little noise and a minimum of friction.

The true forms of wheel teeth which will give a constant velocity ratio are known as the 'epicycloidal tooth' and the 'involute tooth,' the former of which will work with a minimum of friction.

In actual practice wheel teeth are seldom correctly made or properly geared together, and so we experience a great amount of noise and vibration when the gearing is in motion.

Breakdowns are also very common with wheel gearing, for, owing to the back-lash in many wheel teeth, which is set up when a load is suddenly thrown off the machinery, it causes the driven wheels to run back upon the drivers, and the hammer-like action often results in fracture of the teeth.

Breakdowns sometimes are due to the settling of walls and foundations, which cause the cogs of one wheel to lock or jam

with those of the other, and this jamming sometimes occurs through the pedestal bearings becoming worn.

In wheel gearing power transmission is chiefly confined to spur gearing and bevel gearing.

Spur gearing is employed when the axes of driving shaft and driven shaft are parallel.

Bevel gearing is employed when the axes of driving shaft and driven shaft are at right angles.

Angle wheels are employed when a shaft is at any angle with the one from which it is driven.

Mitre wheels are bevel wheels of exactly the same number of teeth. The angle of the teeth is 45°.

Mortice wheels are wheels with teeth of hard wood inserted into spaces cored in the rim. The wood chiefly used is beech, applewood, holly or hornbeam. These wheels are noiseless in their action, and are used at high speeds.
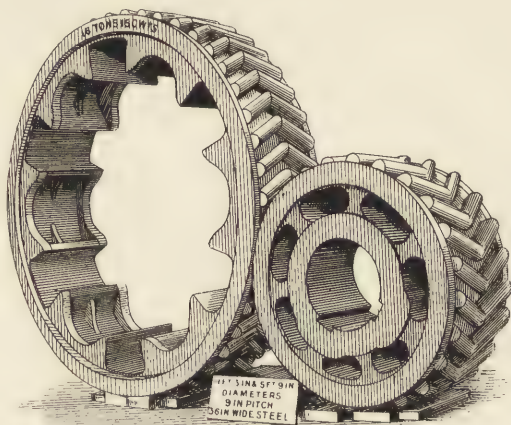
FIG. 144.—PAIR OF HELICAL WHEELS, WEIGHING 28 TONS.

Helical Wheels.—The modern form of wheel tooth is the 'double helical tooth,' which gives great strength of tooth

and large wearing surface. They are used for transmitting large powers at high speeds.

By the kind courtesy of R. J. Jackson and Co., of Salford, we are enabled to give an illustration of the latest form of 'helical wheel' (*see* fig. 144).

The wear of gearing is inversely proportional to the number of teeth, and therefore pinions wear quicker than wheels. To strengthen pinions, 'shrouding' or flanging the sides up to the pitch circle is commonly adopted.

Gun-metal is one and a half times as strong, and steel is from two to four times as strong as cast-iron wheels, and therefore steel wheels are adopted when excessive power and speed are necessary.

Belt Driving.—Belts have been used for a long time for the transmission of small powers, and are very efficient for driving when the centres of shaft are near together. They are commonly used for transmitting power from the line shaft to the machinery ; one great point in their favour is that they can easily be transferred from the fast pulley to the loose pulley when it is desired to stop a machine, or *vice versa*. They are easily twisted or crossed, and are thus extremely useful for driving two parallel shafts in opposite directions.

They are not generally adopted for transmitting large powers, on account of increased space in a gearing chamber, and belting is also very costly, and much attention is needed to keep them in good condition. It is not suitable for main driving when the centres of shafting are too far apart, owing to the great weight of belting, which, besides having plenty of 'gag,' would put a great strain on the shafting and bearing.

Leather belting is the one chiefly used, though cotton and indiarubber belting are now coming forward with special features of their own.

The maximum speed of belting for maximum efficiency is about 3,500 feet a minute.

Method of Calculating H.P. of Belting.—A single belt $1''$ wide at 1,000 feet a minute will safely transmit 1·7 H.P., and a double belt $1\frac{1}{2}$ times the amount. Hence the rule :—

$$\frac{\text{Breadth of belt} \times \text{speed of belt in feet per minute} \times 1\cdot7}{1000}$$

Example.—Find the H.P. which may be transmitted by a pulley $3'0''$ diameter, $4''$ broad, when running 300 revolutions per minute.

$3'\ 0''$ diameter $= (3\cdot1416 \times 3) = 9\cdot4248$ feet circumference.

Speed $= (9\cdot4248 \times 300) = 3727\cdot4$ feet per minute.

$$\text{H.P.} \left(\frac{3727\cdot4 \times 1\cdot7 \times 4}{1000} \right) = 25\cdot3 \text{ H.P.}$$

Rope Driving.—This is the modern application of power transmission, and is fast superseding all other systems. It was introduced on a large scale about 1860. The principle of driving is as follows :—A fly rope pulley keyed on engine crank shaft drives other pulleys on the line shafting in the different rooms of the mill by means of ropes working in grooves which are turned in the outer rim of the pulleys.

The pulleys are commonly made of cast-iron, the fly rope pulley being built up in segments. For excessive speeds (7000 feet a minute) steel rope pulleys have been successfully employed.

The angle of groove varies from 40° to 45°, and the ropes do not rest at the bottom of groove, but are wedged in on the sides, so that slipping is reduced to a minimum ; in fact, there is so little slipping in rope driving that the theoretical and practical speeds are exactly the same.

The ropes are made of either hemp or cotton. In Lancashire cotton ropes are preferred, because of their greater pliability, and because they are easily obtained from yarns spun in the mills.

The breaking strength of ropes (cotton) is from 7,000 to 12,000 lbs. square inch, and for main driving purposes vary in size from 1″ to 2″ diameter.

The average life of a rope is about 10 years, though ropes are still working which were put on 15 years ago.
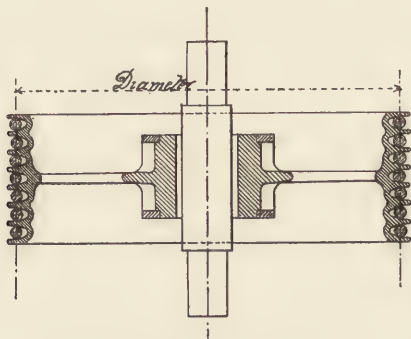
FIG. 145.—SECTION OF ROPE PULLEY.

The limit of speed for maximum efficiency is about 5,000 feet a minute, or nearly a mile a minute, but beyond this speed there is loss of driving power, owing to resistance of the air and to centrifugal force, which tends to throw the rope out of the groove and decrease the grip of the rope in the groove.
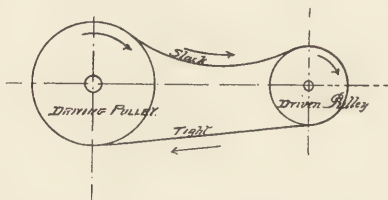
FIG. 146.—SHOWING TIGHT AND SLACK SIDES.

The slack side of a rope should be placed on the top, and the tight, or driving, side on the bottom, so that as great an arc

of contact as possible must be obtained to increase the efficiency of rope driving (*see* fig. 146).

The maximum distance of shaft centres is about 100 feet when the driving is horizontal, though this distance may be increased to 130 feet when the driving is at its most favourable angle, viz. 45°.

The distance from centre of one rope to the centre of the rope in the next groove is known as the 'pitch of the rope' (*see* fig. 147).
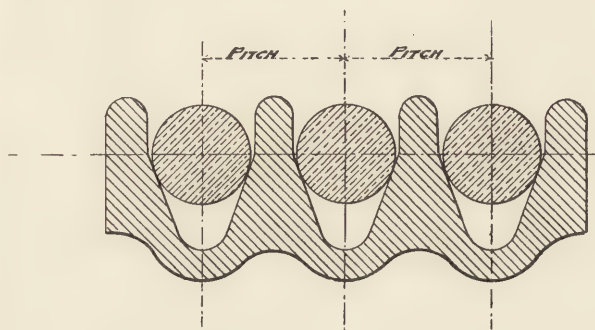
Fig. 147.—Section showing Pitch of Rope.

The diameter of a rope pulley is always measured to centre of rope, and must not be less than 30 times the diameter of rope, owing to the alternate bending and straightening action when the ropes pass over the pulleys. The following table will give the minimum diameter of pulley to suit different diameters of ropes :—

Pulley 2′ 0″ diameter, for rope 1″ diameter
,, 3′ 0″ ,, ,, ,, $1\frac{1}{4}''$,,
,, 4′ 0″ ,, ,, ,, $1\frac{1}{2}''$,,
,, 5′ 0″ ,, ,, ,, $1\frac{3}{4}''$,,
,, 6′ 0″ ,, ,, ,, $2''$,,

The advantages of rope driving are many, among which may be named—

1. Cheaper system than either belting or wheel gearing.

2. The quiet and steady driving of rope gearing is in striking contrast to the noisy, irregular motion of wheel gearing or the heavy slapping of belts in belt driving. The pliability of the ropes also reduces the shock between engine and machinery when a heavy load is thrown off or on.

3. If the shafting is a little out of line, due either to 'settling' of mill walls or to careless workmanship, the ropes will still drive very well.

4. If any changes of speed or rearrangement of machinery be desired, this can be done at little expense.

5. In this system we have practically absolute freedom from breakdown, as when a rope is getting too weak for its work it gives warning, and can easily be taken off and replaced.

6. The gearing chamber may be made narrow, thus effecting economy of space. The power conveyed by the rope may be easily subdivided and transmitted to various parts of the factory.

The loss of power in rope driving by friction is very little, if any more, than wheel gearing, and in many instances in Bolton and district where wheel gearing has been replaced by rope driving, it has been found that no more power has been absorbed by friction of rope gearing than in the former system.

The following table gives excellent results for H.P. transmitted by bottom ropes up to 5,000 feet a minute :—

$1''$ diameter, 3 H.P. for every 1,000 feet per minute

$1\frac{1}{4}''$	,,	5	,,	,,	,,	1,000	,,	,,	,,
$1\frac{1}{2}''$	,,	7·35	,,	,,	,,	1,000	,,	,,	,,
$1\frac{3}{4}''$	,,	10	,,	,,	,,	1,000	,,	,,	,,
$2''$	,,	13	,,	,,	,,	1,000	,,	,	

Fig. 148.—Sections showing Transmission of Power to various Rooms of the Bee Hive Spinning Mill.

Example.—A rope $1\frac{1}{2}''$ diameter moves at 4,000 feet per minute. Find the H.P.

$$\frac{4000}{1000} \times 7.35 = 29.4 \text{ H.P.} \quad Answer.$$

A glance at fig. 148 will show how the power required to work the machines in the various rooms of a modern mill is transmitted by ropes from the engine house. We are enabled by the courtesy of Messrs. Hick, Hargreaves and Co., of Bolton, to show two sections giving details of the driving used in the Bee Hive Spinning Mill, Bolton. The larger of the two sections is taken through the rope chamber and fly wheel. This latter is 26' 0'' in diameter, makes 60 revolutions per minute, contains 40 grooves, for ropes $1\frac{1}{2}''$ thick.

By the rule just given it will not be a difficult matter to calculate what power is transmitted to the four spinning rooms, and to the card room, which is on the ground floor.

H.P. in top room $= \dfrac{4900 \times 7.35 \times 8}{1000} =$ 288.12 H.P.

H.P. in third spinning room $=$ 288.12 H.P.

H.P. in second spinning room $= \dfrac{4900 \times 7.35 \times 7}{1000} = 252.105$ H.P.

H.P. in first spinning room $=$ 252.105 H.P.

H.P. in card room $= \dfrac{4900 \times 7.35 \times 10}{1000} =$ 360.15 H.P.

Total 1440.6 H.P.

CHAPTER XXII

Common Tests applied to Cottons and Yarns.—
The authors are indebted to Messrs. Goodbrand and Holland,
Manchester, for the figures and descriptions used in this
chapter.

Moisture in cotton and yarn is usually tested for in the
following way :—A quantity of cotton is taken from the bale,
and this is placed in a very dry room for some time. It is
then weighed. Five to 8 per cent. is generally allowed for
natural moisture. After allowing for this the difference is
noted, and the percentage of added moisture obtained.
Example : take 20 ozs. of cotton. After drying it weighs, say, $17\frac{1}{2}$
ozs. Five per cent. allowed for natural moisture would give a loss
of $1\frac{1}{2}$ oz. by drying. Hence there is a percentage moisture of $7\frac{1}{2}$.

When, however, an oven is desired, one something like what
is shown in fig. 149 is used. Here the cotton is allowed to
remain heated to a temperature of 170–180° F. for about
one and a half hours. At the end of that time it may be said to
have lost all the moisture it could possibly lose at that tempera-
ure. It is next weighed very carefully. As cottons contain a
small percentage of moisture naturally, it is usual to allow
about 8 per cent. In this case 80 grains would be added
to the weight obtained after drying. It has been found
from a number of experiments that cotton after heating in the
way just described absorbs about 8 per cent. of moisture from
the air, and so in calculating this must be allowed for. After
weighing and adding on the 80 grains, we readily get at the

superfluous moisture contained in the sample selected. If the cotton contains sand, &c., note must be made of this.

Example.—Weight put in the oven, 1000 grains. Weigh taken out, 890 grains. Add 80 grains = 970 grains. Loss on 1000 = 30 grains, loss on 100 $=\dfrac{30}{10}$ or 3 per cent.
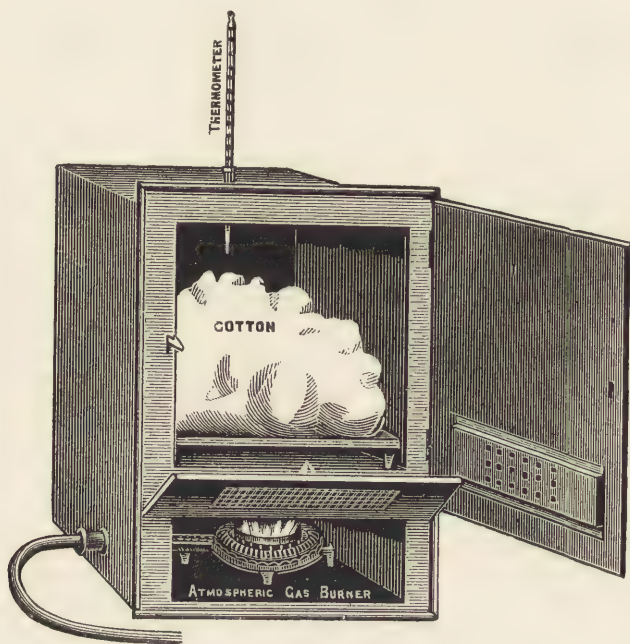
FIG. 149.—OVEN FOR TESTING FOR MOISTURE.

In testing yarns much the same method is followed, only that a greater weight is heated, and for a longer time, say for five hours.

Example.—Weight of yarn put in the oven, 10,000 grains. Taken out, 8,500 grains. Add 500 grains, which equals about 5 per cent. This is generally allowed. Weight then

equals 9000 grains.   Loss equals 1000 grains in 10000, or 10 per cent. of added moisture.

Weighing of Laps from Scutcher.—Fig. 150 shows a very useful form of scale for weighing laps readily as they come from the lap machine.   The scales consist of a circular spring
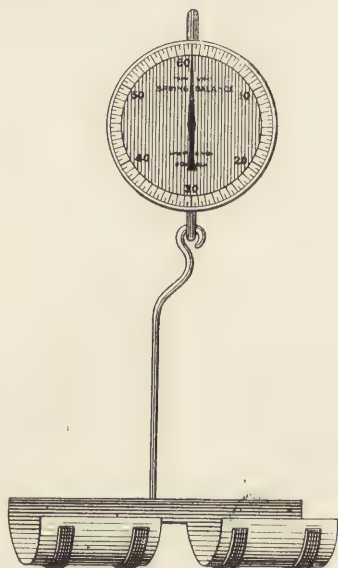
FIG. 150.—LAP SCALES.

balance, a disc 12″ in diameter, and capable of weighing up to 60 lbs. by 2 oz.   The wrought iron arms are sub-stantial and lined with tin, which prevents the tearing of laps as they are weighed.   Records should be kept by the worker of all laps made, and these should periodically come under the eye of the overlooker or manager.

Measuring the Length of Rovings, Slubbings, and Drawings.—For the purpose of ascertaining the counts by measuring the length of cardings, rovings, slubbings and

drawings, what are termed wrap drums, or blocks, are used. Fig. 151 gives a good idea of a useful form of drum.

The circumference of the cylinder is exactly 1 yard, and the mechanism is so arranged that a bell rings when a certain length has been wound on to the drum. The creel is made to hold the bobbin containing the cotton roving under test, and this bobbin readily turns to let off the yarn as it is put on the drum. It is clear that the wrap block must be so constructed that no tension whatever takes place in unwinding. If any does take place, the result will not be reliable.
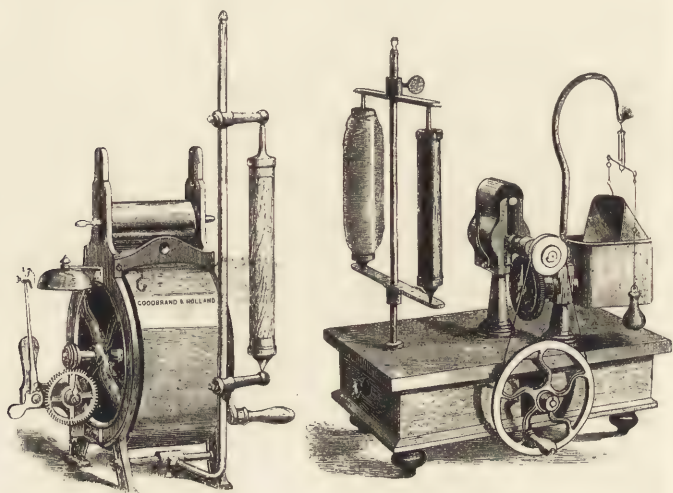
FIG. 151.—WRAP DRUM OR BLOCK.　　FIG. 152.—SELF-REGISTERING ROVING REEL.

For slivers a given length is usually taken, say 2 or 3 yards. A good machine is now on the market which combines measuring, weighing, and indicating automatically. This is shown in fig. 152.

The roving under test is passed through the rollers until a quantity sufficient to balance the weight is put in the pan.

When this is done, note the indicator, the short pointer on the interior circle giving the hank, and the long pointer on the exterior circle giving the decimal part of the hank.

Before commencing to test, see that both fingers on the indicator point to zero.

Measuring and Winding Yarns into Leas or Hanks for Ascertaining the Counts, as well as the Breaking Strengths and Elasticity of the Threads.—Before describing the ordinary methods of testing yarns, the following facts must be stated :—

(*a*) 840 yards of yarn equal one hank ;

(*b*) The number of hanks in 1 lb. avoirdupois equals the counts ;

(*c*) 120 yards or $\frac{1}{7}$ of a hank equals 1 lea ;

(*d*) 7000 grains equal 1 lb. avoirdupois ;

(*e*) 1000 grains equal weight of one lea ; counts being 1.

It therefore becomes a comparatively easy matter to find the counts of yarn when we have the above clearly before us. A hank of 840 yards, and which weighs 1 lb. or 7000 grains, is said to have a counts of 1, because 1 hank of 840 yards weighs 1 lb. Then a lea, which, by statement above, is equal to 120 yards, will weigh $\frac{120}{840}$ of 7000 grains, or

$\frac{1}{7} \times \frac{7000}{1} = 1000$ grains.

This 1000 grains can be used, therefore, as a unit for calculating counts in this way.

Let c stand for the counts, and w for the weight in grains for 1 lea ; then it will be clear that w multiplied by c = 1000 grains—

$$\text{or } w \times c = 1000 \text{ grains.}$$

Dividing or multiplying each side of an equation by the same quantity does not alter it in value, hence—

$$\frac{w \times c}{c} = \frac{1000}{c} \text{ or } w = \frac{1000}{c}$$

$$\text{and } \frac{w \times c}{w} = \frac{1000}{w} \text{ or } c = \frac{1000}{w}$$

We then have a working formula by which we can easily calculate the weight when the counts are given, and conversely when the weight in grains per lea is given we can get out the counts.

Example.—One lea of yarn weighs 50 grains. Find the counts.

$$c = \frac{1000}{50} = 20 \text{ counts.}$$

Carrying this explanation just a little further, a simple rule may be given which will apply to scutcher, card, drawing frame, fly frames and mule; in fact, the counts of yarn, sliver, roving or lap may be found readily at any time by remembering this rule.

The rule just given, viz. $c = \dfrac{1000}{w}$, only holds good when we are treating of 120 yards, or 1 lea. If we only take 1 yard of yarn, it would be altered like this: the 1000 would be divided by 120, and the rule would stand thus: $C = \dfrac{8\frac{1}{3}}{w}$. Of course, there are many objections to taking only a single yard of yarn, but it is the dividend $8\frac{1}{3}$ or $8\cdot3$, which it is desirable to specially make prominent. Suppose we take a yard of the lap from the scutcher and weigh it, we find, say, 11 ozs. is given. The counts will be $C = 8\frac{1}{3} \div 11$ ozs. Remember $8\frac{1}{3}$ are grains, and in 11 ozs. there will be $\dfrac{11}{16} \times \dfrac{7000}{1}$ grains, or $\dfrac{77000}{16}$.

$$\therefore 8\tfrac{1}{3} \div \frac{77000}{16} = \frac{25}{3} \times \frac{16}{77000} \quad \text{or} \quad \frac{16}{9240}, \text{ or } \cdot001 \text{ hank lap.}$$

In the case of a sliver from the draw frame we take 6 yards and the weight given is 12 dwts. 10 grains, or 298 grains. As $8\tfrac{1}{3}$ is the dividend for 1 yard, that for 6 yards will be $8\tfrac{1}{3} \times 6$, and as this is to be divided by the total weight, we get $\frac{25}{3} \times$ $\frac{6}{1} \div 298$, or $\frac{50}{298}$, or ·16 hank drawing.

Now let us take 15 yards of roving from the slubbing frame. The weight, we find, is 6 dwts. 7 grains, or 151 grains. As $8\tfrac{1}{3}$ is the dividend for 1 yard, that for 15 yards will be $8\tfrac{1}{3} \times 15$, and as this is to be divided by the total weight, we get $\frac{25}{3} \times \frac{15}{1} \div$ 151 or $\frac{125}{151}$, or ·802 hank slubbing.

Going next to the intermediate frame, we take 30 yards of roving, and find it weighs 3 dwts. 21 grains, or 93 grains. As $8\tfrac{1}{3}$ is again the dividend for 1 yard, the dividend for 30 yards will be $8\tfrac{1}{3} \times 30$, and as this is to be divided by total weight, we get $\frac{25}{3} \times \frac{30}{1} \div 93$ or $\frac{250}{93}$, or 2·7 hank intermediate.

In the case, say, of the jack frame, it is usual to take 60 yards, and in this test it weighs 2 dwts. 6 grains, or 54 grains. Again $8\tfrac{1}{3}$ is the dividend for 1 yard, and the dividend for 60 yards would be $8\tfrac{1}{3} \times \frac{60}{1}$, and as this is to be divided by total weight, we get $\frac{25}{3} \times \frac{60}{1} \div 54$ or $\frac{500}{54}$, or 9·2 hank roving.

And lastly, when the mule is reached, exactly the same method is pursued. In this case four cops are usually taken and fixed upon the wrap reel, as shown in fig. 153, and 120 yards are tested at a time. The student is particularly requested

to notice what lengths have been taken in testing from the scutcher to the mule.

Scutcher lap	.	.	1 or 2 yards
Drawing sliver	.	.	6 yards
Slubber roving	.	.	15 yards
Intermediate roving	.	30 yards
Jack roving	.	.	60 yards
Mule yarn	.	.	120 yards.

It will be clear why this increase in length takes place. The attenuation which each process results in gives us less and less weight of cotton taking the same length throughout; consequently to make our work easier and the test more reliable we increase the lengths to be tested.

In yarns from the mule 120 yards are taken, and, say, four cops are treated. We then make each test similarly, and average the result.

Our dividend, as before, is $8\frac{1}{3}$ for 1 yard; then for 120 yards it will be $\frac{25}{3} \times \frac{120}{1}$, and this to be divided by the total weight, which is 18 grains, we get $\frac{25}{3} \times \frac{120}{1} \div 18$ or $\frac{1000}{18}$, or 55·5 counts of yarn.

Our second 120 yards gives counts 55·5 ;

Our third 120 yards gives counts 55 ;

Our fourth 120 yards gives counts 53 ;

The average for the four tests being 54·7 counts.

It should be clearly stated that in making these tests no one result is taken as final, but several tests are made and a general average is worked out.

Wrap Reel.—The instrument which is used for testing for counts goes by the name of wrap reel, and one of the best types is shown in fig. 153. This form may be used for either

cops, bobbins, or hank stands. There is in the one shown
accommodation for four bobbins or for four cops. For English
yarns the distance round the swift is 54″, or $1\frac{1}{2}$ yards.
Then 80 threads put on the swift would measure 120 yards, or
one lea, but by an arrangement of wheels the swift revolves
twice for one turn of the handle. This is an obvious advantage,
because a lea is obtained with 40 revolutions of the handle.
When a lea is wrapped a hammer gives notice by striking
a bell fixed to the machine. The best forms of reel also
have indicators fixed on them. It is clear that, in order
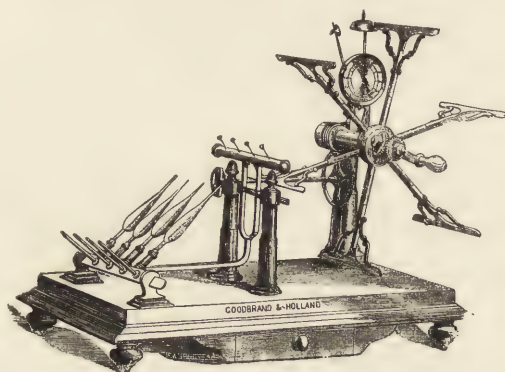
FIG. 153.—WRAP REEL FOR TESTING FOR COUNTS.

to have the test as reliable and accurate as possible, the
threads should be evenly distributed on the reel and each
of equal length. To ensure this an automatic spreading motion
is fixed to the better machines, and any defects in the yarn
are made all the more apparent by this spreading action.

Examining Yarn.—It frequently happens that in the
examination of different yarns comparisons must be made so
far as quality and evenness are concerned. For such a purpose
a machine such as we see in fig. 154 is brought into requisition.
The yarn to be examined is spread evenly on a flat surface,

which is dead black, and when the threads are laid side by side, having proper space between them, irregularities can at once be seen. As in the case of the wrap reel spreading motion, this,
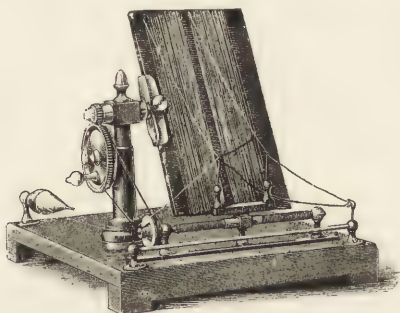
FIG. 154.—YARN EXAMINING MACHINE FOR COMPARING AND SHOWING IRREGULARITIES OF YARNS.

too, has a similar one, worked by the handle wheel. The illustration very clearly shows the method usually adopted in such examination.
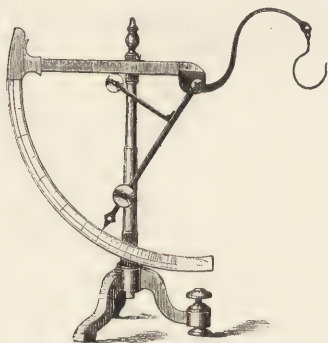
FIG. 155.—HANK QUADRANT FOR FINDING COUNTS, &c.

Hank Quadrant.—If it is desired to find the counts of yarn, &c., without weighing, a most reliable machine is now made, simple in its working and certain in its results. What is called a Hank Quadrant (shown in fig. 155) is used for the purpose. One hank is the usual quantity weighed on this machine, though they can be had to weigh from one to seven leas. The counts from 10's to 100's are read off at once on the quadrant, as shown in the illustration.

Testing for Twist.—It is necessary occasionally for the purpose of comparison to ascertain the amount of twist in single and double yarns.

A glance at fig. 156 will make clear the manner in which this machine is used. The yarn to be tested is placed between the two jaws, one in the vertical limb on the left, and the other in the horizontal one, as shown. Measure say $6\frac{1}{2}''$, and fix the
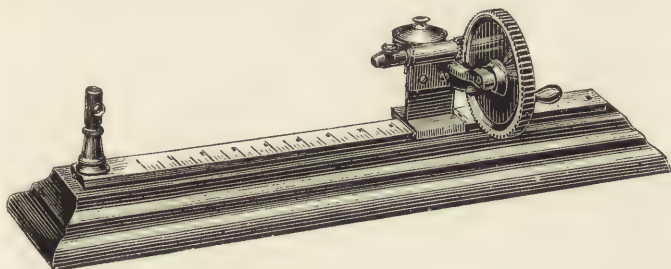
FIG. 156.—TWIST TESTING MACHINE.

yarn, giving a $\frac{1}{4}''$ in each jaw for holding. We have then $6''$ of yarn to be operated on. Put the dial to zero before starting, and notice which way the twist is in the yarn. Then turn the wheel in the proper direction till all the twist is out. Read off the total number given, say 120 ; this gives an average of 20 twists per inch of yarn.

Testing for Strength and Elasticity.—The mode of operation is as follows :—The lea of yarn (80 threads) is placed upon the hooks (*see* fig. 157), or, if a single thread, between the jaws ; when the machine is put in motion, the lower hook descends, causing the yarn, &c., to pull upon the upper hook, causing it also to descend, and the weight and catch to travel up the rack ; when the yarn breaks, the catch at the end of the lever holds the weight in position, and the pointer on the dial indicates the number of pounds at which the yarn has broken.

The elasticity of the yarn is ascertained as follows :—An

indicator is fixed to each hook, which shows the distance each has descended by scales engraved on the tubes. The figures on the upper scale must be subtracted from those on the lower scale ; the difference will be the length the yarn has stretched

Fig. 157.—Yarn Tester for Strength and Elasticity.

before breaking. For instance, if the upper hook has descended 1″ and the lower hook 3″, the difference, viz. 2″, will be the stretch or elasticity of the yarn before breaking.

To test the accuracy or to adjust these machines, first fasten up the catch, to prevent it working in the rack, suspend a standard weight, say, 14, 28, or 56 lbs., by a wire from the upper hook, allowing it to swing free under the bottom bracket. For instance, if tested with 28 lbs. weight, the pointer on the dial should indicate 28 lbs. If it indicates more, or less, remove the bezel and glass from the dial—the pointer being fitted on a cone pivot can be easily withdrawn — place the pointer indicating 28 lbs., which is the weight suspended, press the pointer on to the cone, or a slight tap will secure it. The weight being removed the pointer should then indicate zero, care being taken that the machine is fixed perfectly square before testing.

Should the balance weight on the lever have been moved from its original position, it may require raising or lowering, as the case may be.

CHAPTER XXIII

Mill Construction.—The subject of Mill Construction is an important one from many points of view. In the first place, as mentioned in the chapter on mixing and opening, the greatest facilities should be provided for the easy and economical carriage of the material. Another main point to be considered is the construction of the building itself, having regard to the question of economy of insurance. The prevention of fire is an item to which perhaps more attention is given than to anything else, except the actual equipment, and the fireproofing becomes almost a matter of course when it is decided to erect at all. It might be of use to mention here that the thickness of the walls usually varies according to the number of storeys, as follows :—

Shed : outside walls $1'\ 7''$ or $2'\ 0''$.

	Ground Floor	1st Floor	2nd Floor	3rd Floor	4th Floor
2 storey mill	$2'\ 0''$	$1'\ 7''$	—	—	—
3 ,,	$2'\ 5''$	$2'\ 0''$	$1'\ 7''$	—	—
4 ,,	$2'\ 5''$	$2'\ 0''$	$2'\ 0''$	$1'\ 7''$	—
5 ,,	$2'\ 10''$	$2'\ 5''$	$2'\ 0''$	$2'\ 0''$	$1'\ 7''$

These are brick walls. The thinning of half a brick is taken off on the inside, so that the top room of a mill is the largest, and will in fact contain the longest mules.

As regards the height of rooms, it is the modern practice to build a shed with a distance of about $14'\ 0''$ from floor to the
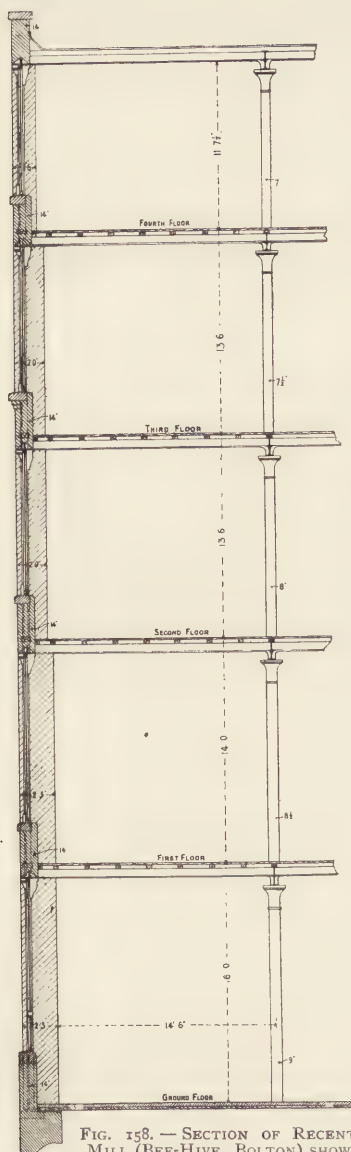
FIG. 158. — SECTION OF RECENT
MILL (BEE-HIVE, BOLTON) SHOW-
ING PARTICULARS OF HEIGHTS
AND THICKNESSES.

under side of the beams sup-
porting the roof. This is
much the same as the height
of the card or bottom room
of a new fireproof mill. The
best system of fireproofing
occupies, say, 18″ to 2′ 0″ in
thickness, including boards
on floor above, so that the
pitch of floors from 'tread' of
card room to that of first
spinning room may be as-
sumed at about 16′ 0″. The
spinning rooms are not so
lofty as the card room, and
these may be reckoned at
·about 13′ to 14′ from 'tread
to tread.' The top room
will be, say, 13′ to the under
side of ceiling beams. Refer-
ence to fig. 158 shows the
section of one of the latest
mills erected in this country,
and gives a very fair idea of
what is the actual allowance
for the various heights of
rooms and thickness of walls.

It is, perhaps, unnecessary
to remark that the mill is
erected to suit the machinery,
and not the machinery to suit
the mill, so that as far as
possible the shafting may be

conveniently carried on pillars, the latter being placed so as not to obstruct the passages. Another modern consideration is that of safety from accidents to life and limb. The latest Act in connection with this enacts that no travelling part of a self-acting mule shall approach any fixture within 18″. This order affects the pitch of the bays in a new mill to a greater extent than at first seems possible. It may be taken to increase the length of a mill by 1′ for every bay. In other words, a bay to contain one pair of mules (ordinary stretch 64″) must be 22′ 0″ wide, instead of 21′ 0″, as formerly. The end bays will consequently be 23′ 0″. There are no pillars in the 'wheel-house' of the mules, but only down the creel alleys, whether the bays are 22′ 0″ or 23′ 0″.

Fireproofing.—The system of *fireproofing* adopted at one of the very latest mills in Bolton (viz. the Bee-Hive Spinning Company) is illustrated in fig. 159. The main girders $15'' \times 5\frac{1}{2}''$
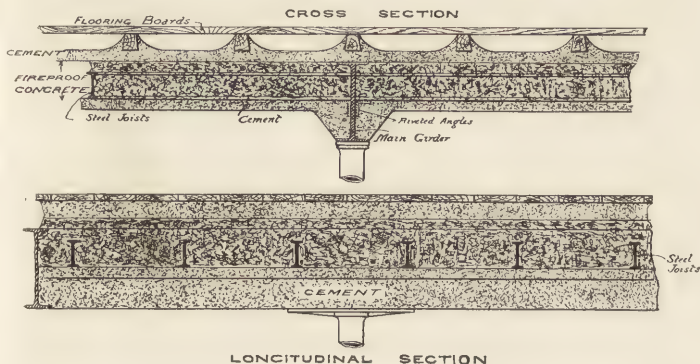
FIG. 159.—SECTION GIVING DETAILS OF FIREPROOFING.

(steel) run lengthways of the building at a distance of 22′ apart. At about half-way up the section of these girders are riveted angle irons, $3'' \times 3''$, on which rest the wrought-iron joists forming the support of the flooring. These joists, it will be seen,

run at right angles to the main girders.   They measure $5'' \times 2''$ in section, and are $1'9''$ pitch.   Between and above these is placed the heavy fireproof concrete, the upper surface of which corresponds to the top flange of the main girders, as shown. On the top of this is a layer of fine concrete or cement $2''$ thick. The wood sleepers to which the flooring boards are nailed rest on the smooth concrete, and are cut out of $3'' \times 3''$, that is, they measure $3''$ in depth and $3''$ in width at the bottom.   Single flooring boards are used $1\frac{1}{4}''$ thick.

The total depth from under side of main girder to surface of flooring boards is thus about $1'\ 10''$.

The under side of the coarse concrete and the iron joists is covered with a $2''$ layer of fine cement or plaster, so that the joists are entirely concealed, as well as the angle irons support-ing them, and the body of the main girders.   The coating of cement is bevelled off to the level of under side of girder as seen. When finished the ceiling of each room is whitened, and presents a smooth surface, with nothing of the constructive parts visible except the bottom flange of the main girders. These are generally painted a bright red, and rather improve the appearance of the ceilings.

Lighting.—There is no doubt that good work largely depends upon the proper *lighting* of a mill, whether by natural or artificial means.   At first sight it would appear an easy matter to provide for the day-time lighting of a mill, but this is not so simple except in the case of a one-storey building, where the whole roof can usually be provided with skylights.   It may be useful to mention here that the north light is usually taken advantage of where possible.   The lighting of a mill several storeys high, and of great width, say $130'$ wide, which is now common, is quite another matter, and many existing mills have badly lighted card rooms, through neglecting to pay proper attention to this point.

The upper storeys of a mill are easier to light from the outside than the card room, because in the former the windows may be placed all the way round (*see* fig. 160), which it is impossible to do in the lower room, because of the engine and boiler houses, rope race, staircase, lodge, &c., which must of course occupy a great part of the ground floor outside the walls of the mill proper. These necessary parts of the building usually deprive the card room of a greater or less quantity of light, but a

FIG. 160.—BEE-HIVE MILL, BOLTON, SHOWING PROVISION FOR LIGHTING.

judicious arrangement may reduce this evil to a minimum. One of the most important, and perhaps one of the most neglected, conditions is the direction of the main girders, which in most mills are *below* the level of the ceilings. It is very important that the ceilings should offer no obstructions to the travel of light from the windows. These convey the light to the interior of the rooms and distribute it, and it therefore follows that if the ceiling is obstructed by girders $12''$ to $16''$ deep the shadows thrown by the latter (and which gradually lengthen as

the bays recede from the windows) cause the ceilings, and consequently the rooms, to be darkened.

It thus becomes advisable to so arrange the rooms that a window can be provided at each end of every bay formed by the main girders—that is to say, the main girders must, if possible, run parallel to the dead wall, and at right angles to two walls, each containing an unbroken line of windows. The method of lighting a mill artificially when daylight is not available is a point on which much diversity of opinion exists. In these times the question becomes one of choice between gas and electricity, the only two systems of artificial lighting in use. Much may be said in favour of both, and it would be hard to say on which side the balance of public opinion lies. Electricity is certainly safer than gas, as it reduces the possibility of fire. The economy of using electricity for lighting purposes is probably not so real as it is sometimes made to appear. We may dismiss the question of cheapness at once, as it is generally conceded that gas is the cheaper. Of course many cases are quoted in which the more modern luminant is found to be decidedly more economical, but, at the same time, many cases exist where the discarding of gaslight has been a financial loss. If cotton spinning has to be carried on scientifically with a view to producing 'quality,' then the method of lighting must be chosen from the standpoint of efficiency. No doubt electric light when properly fitted and regulated, is the best in this respect, but under the best conditions it is seldom as unfailing as well-supplied gas. There is still another thing to be considered, and unfortunately it is too much overlooked, viz. the health of the work people. It is certain that the electric light under any system of lamps, &c., is more or less injurious to the eyes. This fact has become only too apparent in certain mills where electric light has been in use one or two years, and it is a significant fact that a new mill, one of the largest and finest in England,
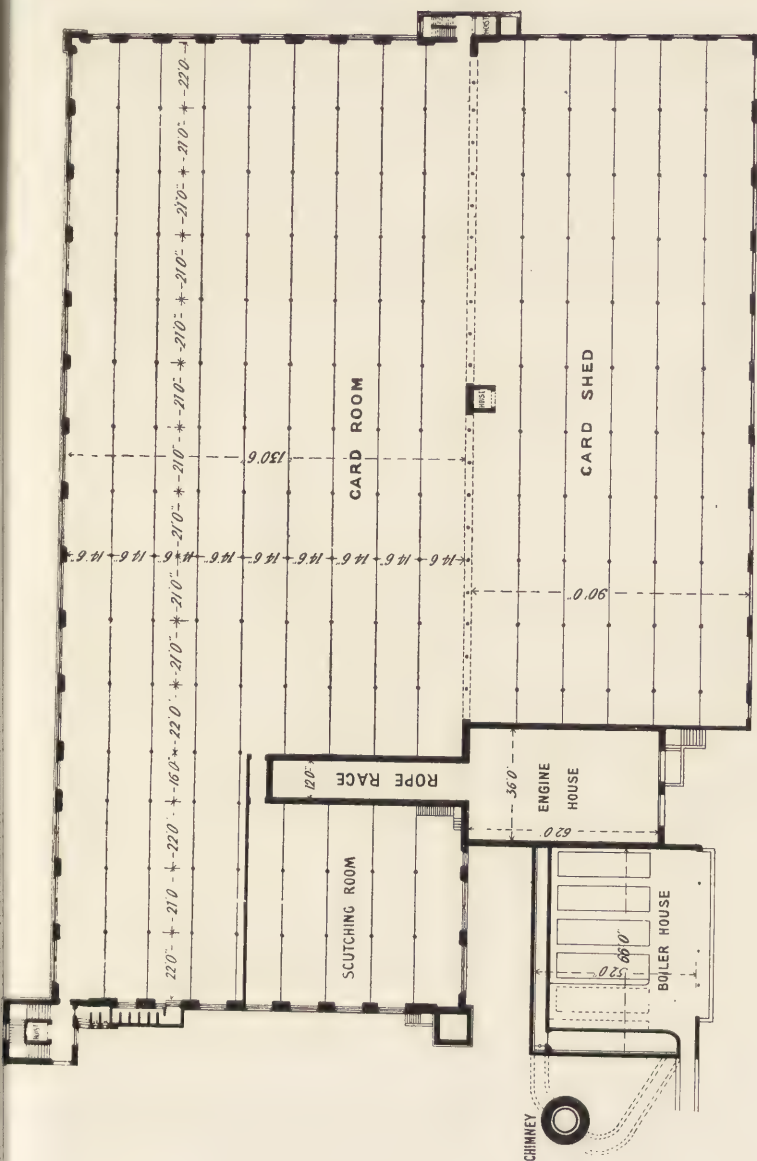
Fig. 161.—Ground Plan of Bee-Hive Mill, Bolton.

A A

just erected, is being lighted with gas, the directors, in face of all known improvements for fitting and using electricity, probably being of opinion that it is advisable to retain good and skilful employees as long as possible.

We are enabled to show the ground plan of one of the most modern mills in this country (*see* fig. 161). It will be seen at a glance how it is proposed to economically dispose the machinery, and what provision is made for economy in driving. This plan should be compared with the elevation shown in fig. 148.

CHAPTER XXIV

Arrangement of Machinery in Mills.—The quantity and specification of machinery necessary to equip a mill depend, first, on the numbers of yarn to be spun and kind of cotton, and, secondly, on the weight to be produced. Figs. 162 and 163 show the setting out of a large mill using American cotton for spinning 32's twist and 45's weft, and producing 39,675 lbs. of twist yarn and 21,638 lbs. of weft yarn per English week of 56½ hours. The mill worked out is a five-storey one, containing 78,384 mule spindles. It is requisite to arrange each spinning room to accommodate an even number of mules so as to place them in pairs, and also to make the rooms of sufficient width to contain mules of up-to-date length, say about 126'. This, allowing 4' for passages, would make the inside dimensions of the building about 130'. It has already been noted in the earlier pages of this work that the cotton mixing and scutching rooms are placed one over another in the order named ; this makes three storeys. But it is usual to carry this part of the building upwards to the same height as that of the mill proper. Consequently the floor space available in the two upper rooms is greater than in the others. The third and fourth spinning rooms therefore will

A A 2
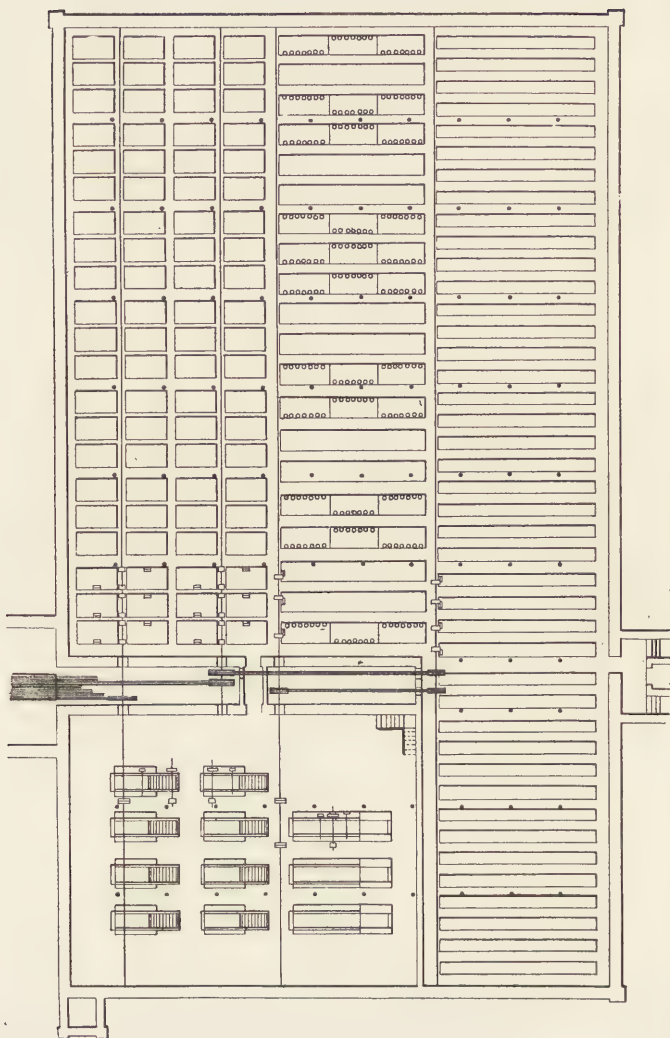
FIG. 162.—PLAN OF MILL FOR SPINNING AMERICAN COTTON. (Ground Floor.)
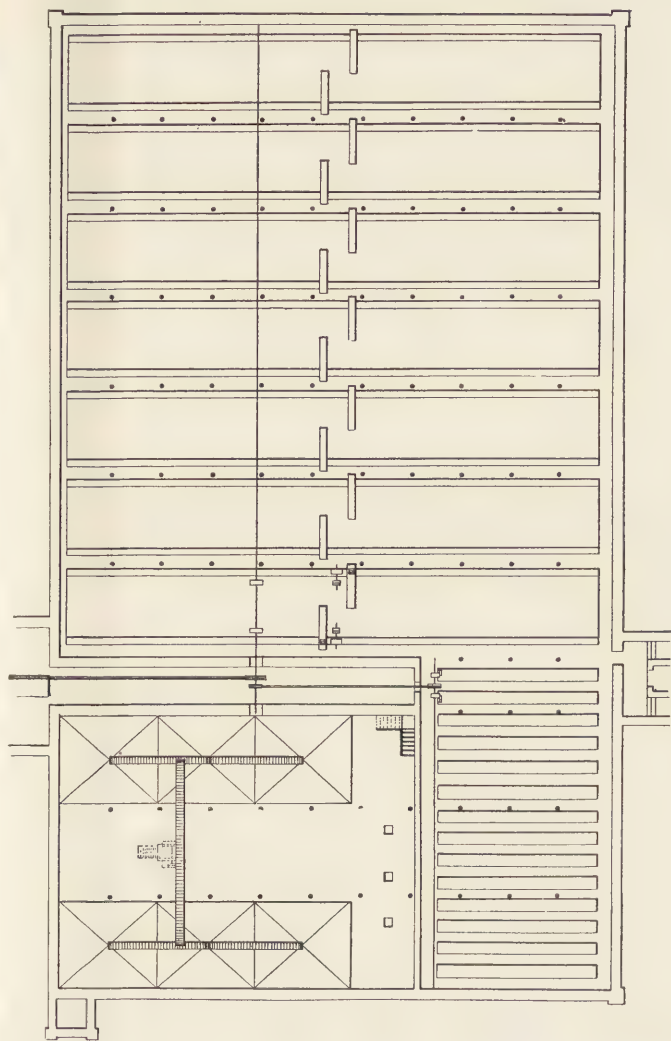
FIG. 163.—PLAN OF MILL FOR SPINNING AMERICAN COTTON. (Above ground floor.)

each contain six mules more than the first and second. The
full number of mules is as follows :—

> First spinning room 14 mules of 1284 weft gauge.
> Second   ,,   ,,   14   ,,   1292   ,,   ,,
> Third   ,,   ,,   20   ,,   1056 twist ,,
> Fourth   ,,   ,,   20   ,,   1060   ,,   ,,

that is, 36,064 weft spindles, and 42,320 twist spindles. Having
found the number of spindles the mill will hold, the amount
of preparing machinery can be calculated. The working is as
follows :—

36,064 weft spindles at 27 hanks per spindle, of 45's =

$$\frac{36064 \times 27}{45's} = 21,638 \text{ lbs. per week.}$$

42,320 twist spindles at 30 hanks per spindle of 32's =

$$\frac{42320 \times 30}{32} = 39,675 \text{ lbs. per week.}$$

Total weight of yarn 61,313 lbs.

It is necessary to make allowance for waste, and this may
be put at about 14 per cent. from raw cotton to yarn, so that
to produce 61,313 lbs. of yarn 69,896 lbs. of cotton will be
consumed. Calculating 2 per cent. waste in spinning rooms,
3 per cent. in frames, and 5 per cent. in cards, opening and
scutching machinery must be provided to produce about 67,500
lbs. of finished laps. The production of a double opener as
shown on the plan is 24,000 to 28,000 lbs. weight, and of a
scutcher 15,000 to 18,000 lbs. per week. The blowing room,
therefore, must contain 3 double openers with hopper feed and
lap parts, 4 intermediate scutchers, and 4 finishing scutchers.

Cards.—A suitable card sliver for preparing these counts
is ·154 hank (or 54 grains per yard), and at $14\frac{1}{2}$ revolutions of
doffer the machine will produce about 766 lbs. per week. This,

divided into 64,378 lbs., gives 84 as the number of cards required.

Draw Frames.—A draw frame delivering 6 ends up and the same hank sliver should produce 830 lbs. with front roller $1\frac{1}{4}''$ diameter and 360 revolutions per minute. 63,889 lbs. divided by $830 = 77$ finishing deliveries.

Slubbers.—The slubbing frame will produce 50 hanks per spindle per week of ·7 hank, so that $\dfrac{63439 \times \cdot 7}{50} = 880$ spindles.

Intermediates.—The intermediate frame will produce 51 hanks of 1·7 hank per spindle per week, hence $\dfrac{62900 \times 1 \cdot 7}{51} = 2096$ spindles.

Roving Frame.—The roving frame should produce 41 hanks per spindle per week of $4\frac{1}{2}$ hank bobbin ; therefore $\dfrac{62539 \times 4\frac{1}{2}}{41} = 6854$ spindles will be required.

The hank slivers above given are selected in accordance with suitable draft in each machine.

List of Machinery required therefore will be

1 Bale breaker, with lattice mixing arrangements.

3 Double cotton openers, with automatic hopper, feeders and lap parts.

4 Intermediate scutchers.

4 Finisher scutchers.

84 Cards, 50″ cylinder, 41″ on wire.

11 Drawing frames, 3 heads, 7 deliveries each.

9 Slubbing   ,,   98 spindles, 8″ space.

16 Intermediate ,,   132 ,, $6\frac{1}{2}''$,,

40 Roving   ,,   172 ,, $5''$,,

14 Mules   1,284 ,, $1\frac{1}{8}''$,,

14 ,,   1,292 ,, $1\frac{1}{8}''$,,

20 ,,   1,056 ,, $1\frac{3}{8}''$,,

20 ,,   1,060 ,, $1\frac{3}{8}''$,,

An arrangement of an Egyptian mill is shown in fig. 164. This is the plan of card room with preparation for 67,744 mule spindles set out for 60's twist.   It is based upon the following weight and productions :—

Machines	Hank Roving	Hanks and Lbs.	Draft	Productions
Card . .	·231	340 lbs.	126	27,260 lbs.
Draw Frame	·231	483 lbs. per del.	6 or 8	27,040 ,,
Slubbing ,,	1⅝	52 hanks	4·87	26,840 ,,
Intermediate ,,	3⅜	50 ,,	5·54	26,660 ,,
Jack ,,	11	38½ ,,	7	26,480 ,,
Mule . .	60's	23 ,,	10·9	25,968 ,, of yarn

Scutcher lap 11 ounces per yard.

List of Machinery.

 1 Bale breaker, with lattice mixing arrangements.
 2 Double cotton openers, with automatic hopper, feeders, and lap parts.
 2 Single scutchers.
80 Cards, 50″ cylinder, 41″ on wire.
16 Drawing frames, 2 heads, 7 deliveries each.
 8 Slubbing   ,,   72 spindles, 8″ space.
12 Intermediate ,,   138   ,,   6½″ ,,
36 Jack   ,,   210   ,,   4¼″ ,,
14 Mules   1,050   ,,   1⅜″ ,,
14   ,,   1,058   ,,   1⅜″ ,,
18   ,,   1,058   ,,   1⅜″ ,,
18   ,,   1,066   ,,   1⅜″ ,,

The mule room plan is not repeated, as the same principle obtains in all.

The third example (fig. 165) is that of a mill spinning combed yarn 80's twist.   The combing process, it must be noted, will take out from 15 to 25 per cent. of waste extra.

BOBBIN.
BOXES
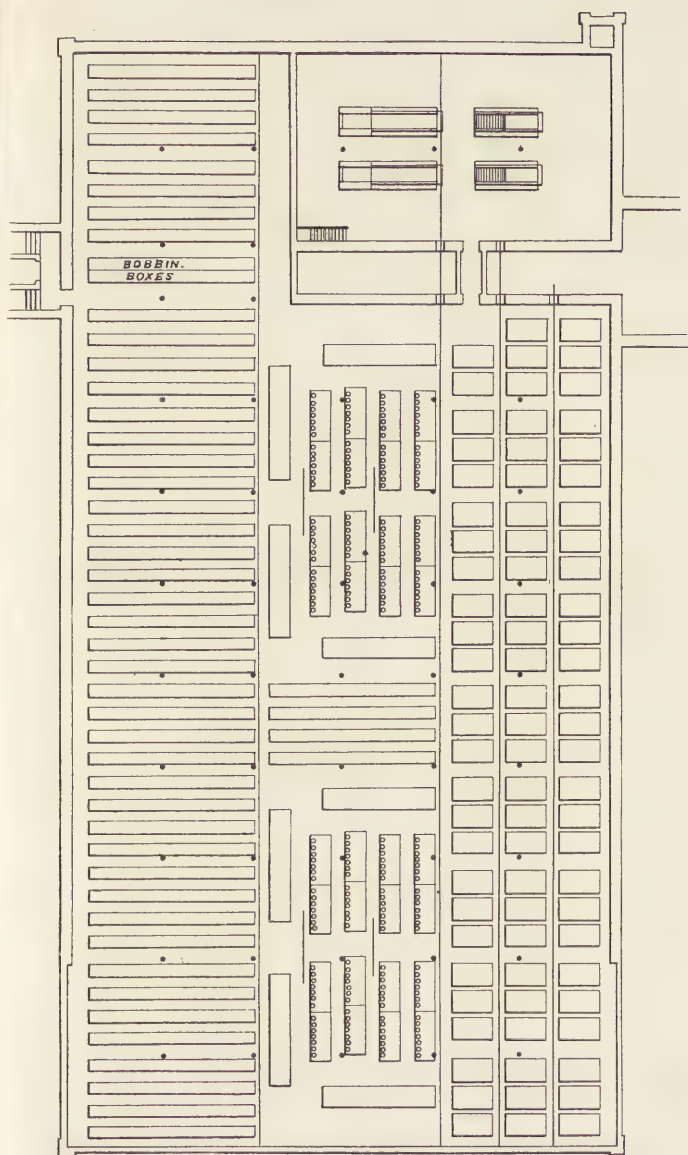
FIG. 164.—PLAN OF EGYPTIAN COTTON MILL. (Ground floor.)

according to class of cotton and quality of yarn. In the following table of weights and productions, the amount of waste made by the combers is about 18 per cent., so that an allowance of 25 per cent. must be made between card sliver and yarn.
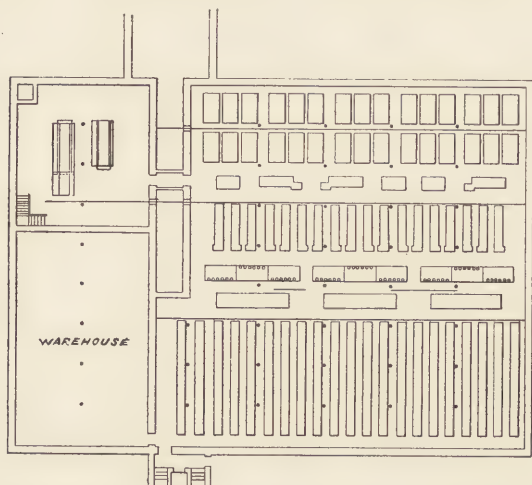
Fig. 165.—Plan of Mill Spinning Combed Yarns. (Ground floor.)

This includes 1 per cent. at lap machine, 1 per cent. at the combined machine, and 5 per cent. for frames and mules, as in the previous examples.

Machines	Hank Roving	Hanks and Lbs.	Draft	Production
Card . . .	·231	312 lbs.	127	9,360 lbs.
Lap machine .	—	3,060 ,,	2	9,180 ,,
Combined ,,	—	3,030 ,,	5	9,090 ,,
Combing ,,	·231	437 ,,	(5 in Draw Box)	7,866 ,,
Draw frame	·231	434 lbs. per del.	6 or 8	7,812 ,,
Slubbing ,,	1¼	51 hanks	5·4	7,750 ,,
Intermediate ,,	4	40 ,,	6·4	7,700 ,,
Jack ,,	14	36 ,,	7	7,650 ,,
Mule . .	80's	20 ,,	11·4	7,500 ,,

Scutcher lap 11 ounces per yard.

List of Machinery.

1 Bale breaker, with lattice mixing arrangements.
1 Double cotton opener, with automatic hopper, feeder and
    lap part.
1 Single scutcher.
30 Cards, 50″ cylinder, 41″ on wire.
 3 Sliver lap machines, $7\frac{1}{2}$″ lap.
 3 Ribbon lap   ,,   6 heads, $8\frac{1}{2}$″ lap.
18 Combing   ,,   8   ,, $8\frac{1}{2}$″ ,,
 3 Drawing   frames, 3   ,,   6 deliveries.
 3 Slubbing   ,,   64 spindles, 8″ space.
 6 Intermediate ,,   128   ,, $6\frac{1}{2}$″   ,,
15 Jack   ,,   198   ,, $4\frac{1}{4}$″   ,,
30 Mules   1,000   ,, $1\frac{5}{16}$″   ,,

CHAPTER XXV

Suitable Data for Mill Planning.--The following tables of suitable hank rovings and productions for the various cards, draw and fly frames, will, it is thought, be a useful guide to students to enable them to plan out mills for themselves. Of course attention must be paid to the length of frames, so as not to get them too long nor too short to be economical in first cost. The number of spindles in each frame given above in the three examples of mills are all of suitable lengths.

Machines	Class of Cotton	Hank Roving	Hanks and Lbs.	Draft
Card . .		·138	1,000	93
Draw Frame .		·126	1,000	5·45
Slubber. .	Indian or Low American	$\frac{1}{2}$	51	3·9
Intermediate .	Cotton	1	58	4
Rover . .		$2\frac{1}{2}$	46	5
Mule . .		16's	33	6·4

Scutcher Lap, $13\frac{1}{2}$ ounces

Machines	Class of Cotton	Hank Roving	Hanks and Lbs.	Draft
Card . .		·138	950	93
Draw Frame .		·138	950	6
Slubber. .	Indian or Low American	$\frac{1}{2}$	51	3·6
Intermediate .	Cotton	1	58	4
Rover . .		$2\frac{3}{4}$	45	5·5
Mule . .		18's	33	6·54

Scutcher Lap, $13\frac{1}{2}$ ounces

Machines	Class of Cotton	Hank Roving	Hanks and Lbs.	Draft
Card . .		·138	900	93
Draw Frame .	Indian or	·138	900	6
Slubber .	Low American	$\frac{1}{2}$	51	3·6
Intermediate	Cotton	$1\frac{1}{8}$	57	4·5
Rover . .		3	43	5·32
Mule . .		20's	33	6·64

Scutcher Lap, $13\frac{1}{2}$ ounces

Machines	Class of Cotton	Hank Roving	Hanks and Lbs.	Draft
Card . .		·154	800	100
Draw Frame .		·154	800	6
Slubber .	American	$\frac{5}{8}$	54	4
Intermediate .	Cotton	$1\frac{1}{2}$	49	4·8
Roving . .		4	43	5·2
Mule . .		30's	32	7·5

Scutcher Lap, 13 ounces

Machines	Class of Cotton	Hank Roving	Hanks and Lbs.	Draft
Card . .		·173	700	104
Draw Frame .		·173	700	6
Slubber .	American	$\frac{3}{4}$	53	4·3
Intermediate .	Cotton	$1\frac{3}{4}$	47	4·6
Roving . .		$4\frac{3}{4}$	40	5·4
Mule . .		40's	27	8·4

Scutcher Lap, 12 ounces

Machines	Class of Cotton	Hank Roving	Hanks and Lbs.	Draft
Card . .		·189	450	113
Draw Frame .		·189	640	6
Slubber .	Egyptian	$\frac{7}{8}$	56	4·6
Intermediate .	Cotton	$2\frac{3}{4}$	52	6·2
Jack . .		9	44	6·54
Mule . .		40's	27	8·8

Scutcher Lap, 12 ounces

Machines	Class of Cotton	Hank Roving	Hanks and Lbs.	Draft
Card . .		·208	400	119
Draw Frame .		·208	570	6 or 8
Slubber .	Egyptian	1	55	4·8
Intermediate .	Cotton	3	50	6
Jack . .		10	42	6·6
Mule . .		50's	25	10

Scutcher Lap, $11\frac{1}{2}$ ounces

Machines	Class of Cotton	Hank Roving	Hanks and Lbs.	Draft
Card . .	Egyptian Cotton	·208	350	114
Draw Frame.		·208	500	6 or 8
Slubber. .		1	55	4·8
Intermediate .		3	50	6
Jack . .		10½	41	7
Mule . .		55's	24	10·46

Scutcher Lap, 11 ounces

For 60's description, *see* Chapter XXIV

Machines	Class of Cotton	Hank Roving	Hanks and Lbs.	Draft
Card . .	Egyptian Cotton	·231	330	127
Draw Frame.		·231	460	6 or 8
Slubber. .		1¼	51	5·4
Intermediate .		3¾	46	6
Jack . .		13	37	6·9
Mule . .		70's	21½	10·76

Scutcher Lap, 11 ounces

Machines	Class of Cotton	Hank Roving	Hanks and Lbs.	Draft
Card . .	Egyptian Cotton	·231	300	127
Draw Frame.		·231	400	6 or 8
Slubber. .		1¼	51	5·4
Intermediate .		4	42	6·4
Jack . .		14	36	7
Mule . .		80's	20	11·4

Scutcher Lap, 11 ounces

For description of 80's combed, *see* Chapter XXIV

Machines	Class of Cotton	Hank Roving	Hanks and Lbs.	Draft
Card . .	Egyptian Cotton	·277	300	138
Lap Machine		—	2,500 to 3,000 lbs.	2
Combined ,,		—	,,	5
Comber .		·208	400	5·8
Draw Frame.		·208	400	6 or 8
Slubber. .		7/8	56	4·2
Intermediate .		2	58	4·4
Roving. .		4½	46	4·5
Jack . .		15½	34	6·8
Mule . .		90's	18½	11·6

Scutcher Lap, 10 ounces

Machines	Class of Cotton	Hank Roving	Hanks and Lbs.	Draft
Card . .		·277	280	138
Lap Machine		—	{ 2,500 to 3,000 lbs.	{ 2
Combined ,,		—	,,	5
Comber .	Egyptian Cotton	·231	360	5·8
Draw Frame .		·231	360	6 or 8
Slubber .		1	55	4·3
Intermediate .		2¼	56	4·5
Roving . .		5½	37	4·8
Jack . .		16½	33	6
Mule . . .		100's	17	12

Scutcher Lap, 10 ounces

Machines	Class of Cotton	Hank Roving	Hanks and Lbs.	Draft
Card . .		·277	260	138
Lap Machine		—	{ 2,500 to 3,000 lbs.	{ 2
Combined ,,		—	,,	5
Comber .	Sea Island Cotton	·231	320	5·8
Draw Frame .		·231	330	6 or 8
Slubbing .		1	55	4·3
Intermediate .		2¼	56	4·5
Roving . .		6	36	5·3
Jack . .		18	28	6
Mule . .		110's	16·7	12·2

Scutcher Lap, 10 ounces

CHAPTER XXVI

Waste Spinning.—The spinning of cotton waste is a branch of business which varies in method very much. The variation is determined by the character of the waste, which may be hard, soft, clean or dirty.

Hard Waste is composed of hard twisted ends of yarn and cop bottoms, mainly the latter, and the first process is to restore the material to its soft and untwisted condition.

Soft Waste consists of comber waste, card room and spinning room sweepings, clearer strippings, and so on.

Sweepings are generally dirty and oily, whilst comber waste and clearer waste are clean.

The material used in waste spinning mills also includes low classes of Bengal cotton, scutcher droppings, card waste, dirty oily cleaning waste from mills and workshops, hard ends from slashing machines, and, indeed, all kinds of short, dirty and otherwise useless staple. The first machine which is commonly used in both hard and soft waste mills is the waste breaking-up machine, which is constructed with 1, 2, 3, 4, 5 or 6 cylinders, according to hardness of material. The softest waste is passed through a one-cylinder machine, which delivers the cotton in a loose, fleecy condition ready for working. The hardest waste, say cop bottoms, &c., contains much twist, and it is necessary to pass it through a six-cylinder machine to loosen and untwist every strand. The effect of this machine on the hardest waste is to reduce it to a beautifully soft state. Other degrees of waste between the softest and hardest, just

referred to, are passed through two, three, four or five cylinders, as required by the relative degrees of hardness. It is important not to treat the material too much, as this will tend to spoil it. Indeed, it is hardly possible to pass soft waste through many cylinders without danger of firing. We may remark that six passages through a one-cylinder machine are sometimes used instead of one passage through six cylinders.

The processes adopted in the various methods of waste spinning (either soft waste, dirty and oily waste, or mill sweepings) in their order, with other particulars useful to the student, are as follows :—

Oily Waste Spinning.—The counts obtainable from this material are from $\frac{1}{2}$'s to 4's.

(*a*) Waste breaking-up machine of one cylinder.

(*b*) Willow with intermittent feed.—This machine cleans the waste from dust and other impurities, then delivers on the floor.

(*c*) Single scutcher.—This makes the material into a lap usually 46″ or 48″ wide.

(*d*) Breaker card with double scutcher lap feed.—This is a roller and clearer carding engine with feed for two scutcher laps. The fleece from the doffer is not delivered into a coiler, on account of the dirty and greasy character of the material, but is gathered by a Scotch feed or cross feed which automatically feeds the next machine.

(*e*) The finisher card.—This is also a roller and clearer card, and, as just explained, is coupled to the breaker. The cotton from the doffer of the finisher is passed through a condenser, as it is called, an apparatus for dividing the width of the fleece into a certain number of parts (for these counts 20 or 22), which are rubbed or condensed and wound on to a large bobbin which is almost as wide as the card. This bobbin therefore contains 20 or 22 ends.

(*f*) Billey.—This is to all intents and purposes a spinning mule, but, instead of having an upright creel to contain roving bobbins, a low creel is provided, to accommodate the long condenser bobbins just mentioned. They are laid horizontally, and each bobbin feeds as many spindles as there are ends to the bobbin.

This is the complete process necessary to spin such counts as these from oily waste.

Soft Waste Spinning.—The best soft waste, if it is very clean, will spin from 5's to 8's or 10's, according to quality. The machines are—

(*a*) Waste breaking machine with one cylinder and with soaper attached.—This is an appliance for making the cotton greasy by means of soapy water. (It is not used for oily waste, as that is sufficiently greasy.)

(*b*) Willow, with intermittent feed.

(*c*) Single scutcher, 46″ or 48″ lap.

(*d*) Breaker card, 48″ or 50″ on wire.—This machine is not coupled, but delivers into one or two coilers, as in ordinary carding.

(*e*) Derby doubler.—This is a lap making machine with < -shaped table. Sixty slivers in cans from the breaker cards are fed up, thirty on each side of the table, and these are combined and form one lap, generally about $23\frac{1}{2}''$ to $24\frac{1}{2}''$ wide. Two of these laps are placed end to end on the finisher card.

(*f*) Finisher card with double condenser, that is, two bobbins of, say 32 ends per bobbin.

(*g*) Billey.

Hard Waste Spinning.—The system of hard waste spinning, say mostly cop bottoms, is as given in the following list :—

(*a*) Six-cylinder waste machine with soaper.

(*b*) Willow.

(*c*) Single scutcher, 46″ or 48″ lap.

(*d*) Breaker card, 48″ or 50″ on wire.

(*e*) Derby doubler, 60 ends up.

(*f*) Finisher card with condenser.

(*g*) Billey 14 to 34 ends up, according to counts.

The billeys used in waste spinning are usually of 72″ stretch. The gauge varies from $1\frac{5}{8}$″ to 3″, according to counts, for twist, and $1\frac{1}{4}$″ to $1\frac{5}{8}$″ for weft. The billey differs from the mule in having only one line of rollers top and bottom, so that *there is no roller draft*. The draft is put in by the carriage, as gain. After the rollers have delivered a certain length, according to counts, they cease to revolve, and the carriage draws the yarn out.

Productions. — The production of a waste breaking-up machine is 80 to 100 lbs. per hour.

The willow will produce up to 20,000 lbs. per week of $56\frac{1}{2}$ hours, while the scutcher will produce 12,000 lbs. weight of laps.

The breaker and finisher cards when coupled will get through 20 to 30 lbs. per hour at 170 revolutions of cylinder for soft waste, and from 12 lbs. for 10's to 30 lbs. for 2's per hour for hard waste; speed of cylinder 120 to 150.

The billey will produce 8 lbs. per spindle of average 2's, 7 lbs. of 3's, 6 lbs. of 4's, and so on, diminishing to $1\frac{1}{2}$ lbs. of 10's per week of $56\frac{1}{2}$ hours.

CHAPTER XXVII

Mill Insurance.—Within recent years a most remarkable reduction in the number of mills totally destroyed by fire in the cotton manufacturing districts of Lancashire has taken place. The cause for this is not far to seek.

Twenty or thirty years ago cotton spinning was a risky business so far as liability to fire was concerned. It is not to be wondered at that Companies at first sought to keep the maximum amount for which insurance could be effected as low as possible, because it became a serious matter to any office which had several claims to meet in any one year. On the other hand, owners were anxious to be covered in case of fire, and were glad to make proposals which would wholly or partly remove their liability and bring relief to them in the event of a fire.

The maximum amount which Companies originally fixed upon was something between 2,500*l.* and 3,000*l.*, and now it is generally understood that not more than 5,000*l.* is accepted on account of any one risk. Of course larger sums are accepted, but these are spread over a number of offices, and in this way the risk is distributed.

Thirty or forty years ago the rate of insurance so far as mills were concerned was high, but within recent years improvements in mill construction, and other causes, have all tended in the direction of substantially reducing the premiums formerly paid ; in fact, in some cases almost startling reductions have been made. Before dealing, however, with the influences which have

been steadily acting in reducing rates, it is proposed to make a few general statements dealing with mill insurance. The authors here gratefully acknowledge the kind assistance given by Mr. P. Kevan, of the Bolton Mutual Office, in supplying much useful and valuable information found in this chapter.

The amount which is annually paid by the owner or owners of a mill or mills is called the ' Premium,' and the sum which is paid for every 100*l*. insured, whether on the buildings or contents, is called the ' Rate per Cent.'

It must be clearly understood that these rates vary from time to time, and in this chapter it is not intended to deal with what may now be fitly termed the ' Science of Insurance.' This term certainly covers the study of the causes of these variations, but as there are clearly well defined lines which the best Companies act upon, it is with these that it is now proposed to deal.

Fire Insurance Companies are divided into two classes—

(*a*) Tariff Offices ;

(*b*) Non-Tariff Offices.

The ' Finance Chronicle ' of August 1, 1896, gives forty-four British offices in Class (*a*), and thirteen in Class (*b*).

The offices in Class (*a*) are in federation or union, and act and work in common with each other. When revisions of rates are desirable, they usually combine together, and work by what is known as a ' Tariff of Rates '—hence the name. Companies not in this union and working upon independent lines are called ' Non-Tariff Offices.'

It sometimes happens that for some reason or other a mill may be idle, that is, the machinery is standing and is not being worked for the purposes of manufacture ; in this case it is often the rule to charge a net rate, and this goes by the name of ' Silent Rate.'

By the term ' Non-Fireproof ' is included all mills having

wood beams and floors with or without lath and plaster ceilings, and the term 'Fireproof' includes those storeys of a mill in the construction of which no lumber is used save and except mill doors which are external and window frames. When the floors have been concreted and boards are placed upon them, it is usual to allow that the said boards are not part of the structure.

Determining Factors in Insurance.—The *height* of the mill, or, more properly speaking, the number of storeys, is a factor which affects the rate of insurance. Generally speaking, four storeys is the maximum allowed for ordinary rates, and if above these four storeys there is a fifth or a sixth, then an additional amount per storey is charged. It will be clear why this is so. The difficulty of coping with a fire in a fifth or sixth storey is greater than with one in a third or fourth, and as there is a greater probability of being unable to cope successfully with a fire in a fifth or sixth storey, the insurance rate is affected in consequence, and something like $3d$. per cent. is charged for each storey extra, including the fifth and sixth. In the case of a non-fireproof mill fitted up with automatic sprinklers, and in the case of fireproof and sprinkler-fitted mills also, an extra $3d$. per cent. is charged only on the fifth and sixth storeys.

Then, again, the operations carried on in a mill are not all equally *dangerous*, and, this being so, variable rates are charged. Sometimes, however, a lumping is allowed, and it may happen that warehouses, cotton in bale rooms, mechanics' and carpenters' shops, oil and general mill stores, engine and boiler houses, are all taken for a lump sum, but they must not be in open communication with the mill. Differences, again, obtain as between non-fireproof and fireproof buildings, and for the buildings just named a rate of something like $3s$. per cent. would be charged if non-fireproof and without sprinklers, and $1s$. $6d$. with sprinklers. If fireproof, then the rate falls to $2s$. without

sprinklers, and 1*s.* 6*d.* with sprinklers. The various rooms of a mill may be arranged in order of risk as follows :—

1st. Most dangerous and highest rated is the blowing room, in which are performed opening and scutching.

2nd. Mixing room.

3rd. Mule spinning room.

4th. Ring and throstle spinning room and doubling.

The preparatory processes of scutching and opening have always been considered the most hazardous in a cotton mill as regards fire risk, and the rooms in which these processes are carried on should always be of fireproof construction and communicate with the adjoining rooms and buildings by means of a fireproof passage or passages at least 10 feet long, having a fireproof door at each end. As showing the variation in the rates charged, we may state that if the rate per cent. for a non-fireproof mill with sprinklers of 30,000 spindles were 8*s.* 7*d.* for the spinning rooms, something like 12*s.* 8*d.* per cent. would be the rate for the blowing room. If, however, the latter were not protected by a sprinkler installation, the rate would be something like 25*s.* to 30*s.* per cent., an enormous difference.

The *number of spindles* which any mill possesses is also a determining factor in reference to differential rating. A minimum is usually taken, say, any number of spindles up to, but not including, 10,000 ; mills having any number below this all being placed on one rate.

The gradation is usually as follows, the increase in the rate being something like 6*d.* to 1*s.* for each additional 10,000 spindles:—

1. Containing under 10,000 spindles.

2. Containing over 10,000 spindles and under 20,000 spindles.

3. Containing over 20,000 spindles and under 30,000 spindles

4. Containing over 30,000 spindles and under 40,000 spindles.

5. Containing over 40,000 spindles and under 50,000 spindles.

6. Containing over 50,000 spindles and under 60,000 spindles.

7. Containing over 60,000 spindles and under 70,000 spindles.

We believe it is fairly well agreed upon by Companies to classify spinning mills into two divisions, those mills in which the counts spun are 80's and upwards falling into Class 1, and those spinning below 80's falling into Class 2. It may not be quite clear on the face of it why differential rating should obtain especially in the *case of counts*, but upon careful consideration it is seen to be a fair and safe arrangement. In mills spinning low counts a greater weight of cotton is used than in mills spinning fine counts. This being so, the risk of fire is very much greater, as a vast amount of fluff and fly are among the necessary evils of spinning low numbers. *The quality of the cotton used* is also a determining factor in rating. Only the best cottons can be used for spinning high numbers, and experience shows that these are freest from impurities of sand, &c.; consequently there will be less risk of firing when using the best cottons, and therefore the rates are less. Then, again, there will be very much more friction in a low counts mill than in a high one, as a greater weight in a working week is put off. Consequently there must be a greater chance of firing, and therefore the rate of insurance must go up.

As a rule, ring and throstle spinning mills are put upon a slightly different rate than mule spinning mills, the difference being in the case of non-fireproof mills fitted with automatic sprinklers something like 2s. per cent. less. The same rule

of an additional rate applies here in the case of any storey above four.

In connection with mixing rooms, it is sometimes a condition in the insurance policy that if waste is used which has been bought outside, an additional $3d.$ per cent. is made in the case of sprinkler-fitted rooms.

The Average Clause.—It is not an uncommon thing now for Insurance Companies to insert in their policies or agreements a clause which is known as ' The Average Clause ' or ' Condition of Average.' Now this works out in the following manner : A property has been insured for say 5,000*l.*, which is much below its real value, and it has been insured under the condition of average. If a fire takes place in this property, which has been found collectively to be worth say 8,000*l.*, then the insured shall be treated as though he had insured this difference—3,000*l.*—himself, and this amount is made to bear a proportionate share of the loss. In this case, therefore, instead of getting 5,000*l.* he would only get 3,125*l.* That is, the 3,000*l.* would bear ⅜ths of the 5,000*l.* loss, and the 5,000*l.* would bear ⅝ths of the 5,000*l.* It is probable that, as a rule, insurers do not insure their properties for anything approaching their full value, and this clause has been expressly inserted with a view to safeguarding the interests of the various Companies.

Thus far nothing has been said about the insurance of fireproof mills, and it is in dealing with this class that we see the greatest reductions. The rate charged say for a mill four storeys in height, and containing under 10,000 spindles, would be for the building 3*s.* per cent., and for contents 6*s.*; but in case an installation of automatic sprinklers is put in, the rate drops for buildings to 1*s.* 6*d.*, and for contents to 3*s.*, a remarkable reduction. In some cases even a greater reduction—60 per cent. – is made.

Much the same rule is followed in differential rating as to

number of spindles, height of mill, and counts of yarn spun, as in the case of the non-fireproof mills. In some offices this rule obtains, that for mills without sprinklers, the buildings and gearing may be insured together in one sum, without average, at an extra rate of 6*d.* per cent. per annum beyond the rate chargeable for the building, and 3*d.* per cent. for buildings fitted with sprinklers.

Quite recently the question of building only non-fireproof mills, and fitting them up with sprinklers, has been advocated. It is well known that the cost of erecting a fireproof mill is a very much more expensive matter than building one of non-fireproof construction, and a case is known where it was considered a much cheaper matter, even paying the higher premium, to build a non-fireproof mill, but installed with sprinklers.

It will have been gathered from the foregoing paragraphs what have been the most important agencies in effecting reductions of insurance premiums. These are—

(*a*) Automatic sprinkler ;

(*b*) Fireproof constructed mills ;

(*c*) General improvement in fire appliances.

The following will doubtless be interesting, as showing the enormous advantages of being protected by sprinklers. This valuable information is from a reliable authority.

The number of cotton mill fires in this country from 1888 to 1891 was 301 ; of this number 177 were in mills not protected with sprinklers, and 134 in mills protected. The losses in both cases were as follows :—

UNPROTECTED RISKS

Year	Fires	Total Loss			Average Loss per Fire		
		£	s.	d.	£	s.	d.
1888	49	194,780	0	0	3,975	12	0
1889	47	113,734	0	0	2,420	0	0
1890	48	197,525	0	0	4,115	2	2
1891	33	98,398	0	0	2,982	0	0

Total number of fires, 177, with a total loss of 604,437*l.* ; average loss per fire, 3,414*l.* 18*s.*

PROTECTED RISKS

Year	Fires	Total Loss			Average Loss per Fire		
		£	*s.*	*d.*	*£*	*s.*	*d*
1888	21	3,814	15	9	181	15	0
1889	32	7,483	0	0	233	16	10
1890	40	7,368	10	0	184	4	3
1891	41	4,266	0	0	104	0	0

Total number of fires, 134, with a loss of 22,932*l.* 5*s.* 9*d.* ; average loss per fire, 171*l.* 2*s.* 9*d.*

The above figures show that the losses are nineteen times greater in those mills where sprinklers are not fitted than in those that they are.

Automatic Sprinklers.—Within recent years a most important development has taken place in what is now known as the 'Automatic Sprinkler.' Bolton, Lancashire, was the first place in this country to adopt the system of a sprinkler installation, and this was about the year 1880.

An old mill is still standing in the town in which the first trial took place. A Mr. Parmalee fitted up an installation, and combustible materials were gathered together in the mill and fired. The experiment was very successful, and immediately afterwards several mills were fitted up with sprinklers. Insurance Companies encouraged their adoption by making considerable reductions ; in fact, the sprinkler has done more than anything else in effecting substantial reductions in the rates.

Sprinklers vary in form, size, and action of working, and they are of two chief types, viz. 'Sealed' and 'Valved.' At present only three or four kinds of sprinkler are on the market, and most of the installations now fitted up belong to one or other of these four.

We are permitted by the courtesy of the makers to figure and describe two of these sprinklers, and while the authors offer no opinion as to the relative merits of either, they leave the readers to form their own opinions after reading the descriptions of each machine.

Fig. 166 shows roughly how sprinklers are distributed over a room. They have each an effective working distance, and
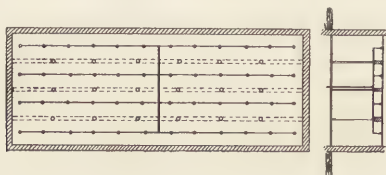
Fig. 166.—Distribution of Automatic Sprinkler in Plan and Elevation

this being known, they are so placed that all the floor space shall come under their influence when in action.

All the water pipes to which the sprinklers are attached run either to—

    (*a*) An elevated tank connected with the public mains ;

    (*b*) Or an elevated tank and fire pump ;

    (*c*) Or are connected directly with the town main.
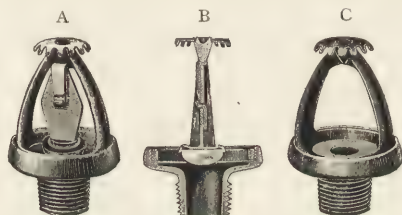
Fig. 167.—The 'Grinnell Sprinkler.'

In fig. 167 is shown three views of what is known as the 'Grinnell' sprinkler. A shows the sprinkler closed, B shows a

sectional view, and c represents the sprinkler open for the discharge of water. This type is simple in its action and construction.

The valve seat, as will be readily understood from the diagram, is forced against the valve by the water pressure, and by reason of this construction the pressure of the water tends to tighten the valve. The valve is a hemispherical disc of glass, with a perfectly smooth fire-glazed surface. It is held to its
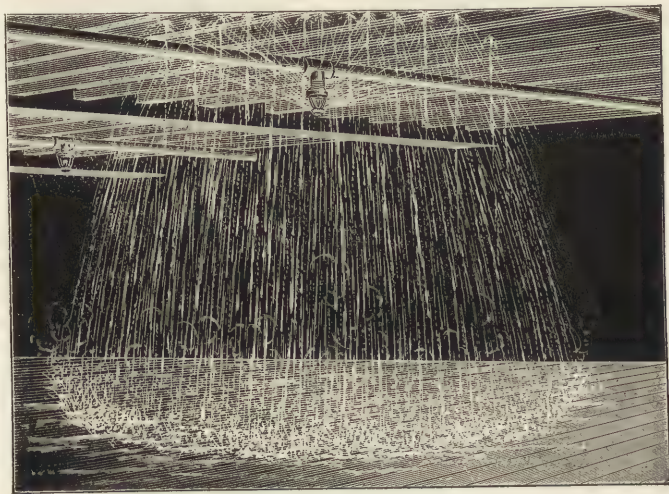
FIG. 168.—ILLUSTRATING DISTRIBUTION OF WATER BY SPRINKLER.

seat by a strut, composed of three pieces, which are joined together by fusible solder. These are the only parts of the sprinkler required to move to liberate the valve. Should a fire start at any point, the heat at once rises to the ceiling, where the temperature is very soon raised sufficiently to melt the solder (which fuses at 155° F.) ; the elastic valve in the sprinkler is thereby released, and the water is profusely distributed on the fire, as shown in fig. 168.

It will be seen on referring to fig. 169 that the internal
arrangement of what is known as the ' Witter ' Sprinkler differs
from the preceding type.　Three views are given of this :　A
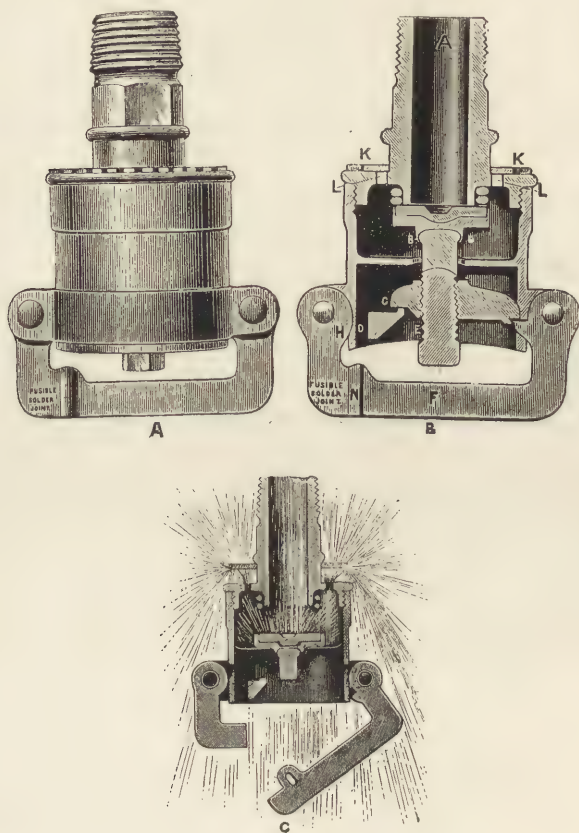
Fig. 169.—' Witter Sprinkler.'

shows the sprinkler closed, B gives a sectional view, and C
represents the sprinkler in action.　It will be noted that upward
as well as outward and downward streams are shown.

In the section (fig. 169 B), A represents the sprinkler stem which screws into the water pipe. F is the swing lever soldered to H with fusible metal, C a bridge supported on fixed bar D and on lever F. E adjusting screw, passing through bridge C and holding valve B to its seat. G chamber. K deflector, which is lifted when in action by the water running through opening L. This deflector also covers the openings when not in action, and prevents them from being filled with dust or dirt. N fusible metal joint 155° F.

It should be stated that to each of these systems is attached an automatic fire alarm, which commences to ring immediately on the outbreak of fire, and this continues ringing until stopped.

CHAPTER XXVIII

Wages.—The Bolton List has for its basis a mule 420 spindles long, spinning 50's, with the standard turns of twist per inch. The prices per 1,000 hanks, using the units just named, are fixed as follows :—

Twist yarn ($1\frac{1}{4}''$ gauge and over), 21·04*d*. per 1,000 hanks.
Reeled or bastard twist yarn, 19·8*d*. per 1,000 hanks.
Weft yarn ($1\frac{1}{8}''$ gauge or under), 18·56*d*. per 1,000 hanks.

The standard turns per inch for any counts to be ascertained are as follows :—

$$\text{Twist} = \sqrt{\text{counts}} \times 3\text{·}606$$
$$\text{Reeled} = \sqrt{\text{counts}} \times 3\text{·}394$$
$$\text{Weft} = \sqrt{\text{counts}} \times 3\text{·}183$$

For 50's the twists per inch are therefore :—

$$\text{Twist yarn} \quad \sqrt{50\text{'s}} \times 3\text{·}606 = 25\text{·}5 \text{ turns}$$
$$\text{Reeled yarn} \quad \sqrt{50\text{'s}} \times 3\text{·}394 = 24\text{·}0 \quad \text{,,}$$
$$\text{Weft yarn} \quad \sqrt{50\text{'s}} \times 3\text{·}183 = 22\text{·}5 \quad \text{,,}$$

From the above standard prices there is deducted $\frac{1}{2}$ per cent. for every twelve spindles above 420, up to and including 806 spindles for all yarns spun upon twist gauge, as before defined ($1\frac{1}{4}''$ and over), and $\frac{1}{2}$ per cent. up to and including 900 spindles when the gauge is $1\frac{1}{8}''$ or below. If, however, the number of spindles does not exceed 804 on one mule, an addition of 5 per cent. must be made to the price. In *twist yarns* all counts below 32's ; in *bastard yarns* all below 34's ; and in *weft yarns*

all below 36's to be paid the same price per 1,000 hanks as for 32's, 34's, and 36's respectively, and 5 per cent. is to be added for 40's and below for all sorts of yarn.

Table of Special Allowances. *Variations in Twist.*— If more than the standard turns be put in, the price must be increased by two-fifths the difference in price between the counts spinning and the counts for which twist is being put in. If less than the standard be put in $2\frac{1}{2}$ turns less make no difference, but the price is reduced by one-fifth the difference as above for each turn beyond the $2\frac{1}{2}$.

Re-banding.—$3\frac{3}{8}d.$ per 100 spindles to be allowed.

Turning Spindle Bands.—$2\frac{1}{4}d.$ per 100 spindles to be allowed.

Double Deckers.—5 per cent. extra to be allowed.

Bobbin Carrying.—As per agreement in individual cases.

Re-setting, &c.—21s. per week, or 30s. for the spinner if one mule be run.

Single and Double Speeds. —Where these are used 5 per cent. to be added.

Tubing varies considerably according to the size of the mule, counts, &c. The price is, for example, 8d. per set for counts from 82's to 100's large cops, on a mule containing 900 to 948 spindles.

For *Pin Cops* the rate is one-eighth of a penny per lb. weight of yarn, when spinning 60's to 100's. These prices are for tubing without apparatus, and with tubing apparatus it is two-thirds the above rates for 100's or over, and two-fifths for 98's or under.

Speeds.—The speed clause of the Bolton list is somewhat vague and liable to be misconstrued. At the present time negotiations are being carried on with reference to its improvement.

The Oldham list is especially clear upon this point, better, in fact, than any other list.

Bolton, Blackburn, Oldham, Hyde, Ashton-under-Lyne, and Preston all have lists of their own, but the main principles of all are embodied in the foregoing conditions.

On page 11 of the Bolton Schedule is given a table of net prices per 1,000 hanks for counts, varying from 32's to 120's; in each case this is for a mule containing 420 spindles spinning twist, reeled, bastard, or weft yarns.

From these particulars it is easy to ascertain the price per 1,000 hanks for any size of mule. Take, for example, 100's twist spun on a mule 910 spindles long. The list price is given as 29·74d. per 1,000 hanks. From this must be deducted 16 per cent. total, or $\frac{1}{2}$ per cent. for every 12 spindles above 420, up to and including 804 spindles.

$$100 : 29\cdot74 :: 16 : 4\cdot75$$
$$29\cdot74 - 4\cdot75 = 24\cdot99d. \text{ per 1,000 hanks.}$$

In Bolton it is a very common practice to pay so much per 100 lbs. The calculation worked by this method will come out like this:—

In 100 lbs. of 100's counts there are 10,000 hanks, and therefore the price will be:—

$$1,000 : 10,000 :: 24\cdot99 : 249\cdot9.$$

249·9d. is the net price per 100 lbs.

In actual practice a spinner would simply look at his list, and would there find the price per 100 lbs. ready worked out, either at net, 5 per cent. above, or 5 per cent. or 10 per cent. below the standard, as the case might be. He would then have to make allowance for any variations in twist per inch, tubing, &c.

Suppose a minder produces 360 lbs. of 100's, what would be the wages on the ticket?

$$\frac{249\cdot9 \times 360}{100} = \frac{2\cdot499 \times 360}{1} = 899\cdot6 \text{ pence, or } \pounds3 \ 14s. \ 11\frac{1}{2}d.$$

The Oldham List.—In this list a different basis altogether is taken from that obtaining in Bolton or any other district. It may be termed a speed list, whereas Bolton list is a counts list, and Ashton is a twist list, the size of the mule of course largely influencing the result in all the lists.

The standard speed for a mule of any size, and spinning any counts, is taken at 3 stretches of $63''$ long, in 50 seconds. At this speed a table of total wages per week is given for all sizes of mules, with the percentage of the total which the minder should retain for himself, and the percentage he should pay to the piecers.

As an indispensable adjunct to this speed list, there is also a table specifying the amount to be added to the wages for each second the mules run quicker than 3 stretches in 50 seconds, according to the size of the mule. If the length of stretch varies from $63''$ to $66''$ the wages are affected in the same ratio, *e.g.* the wages for a $66''$ stretch would be increased a twenty-first part more.

It must not be inferred from what has been said that a minder will have a fixed wage per week according to list, as such is only approximately the case, as demonstrated below.

The basis or principle involved may be summed up in a few words, as follows : According to the size of the mule the total wages as per list should be a certain amount, and, according to the speed, and size and counts, the hanks produced should reach a certain total.

These two terms (size of mule and hanks produced) having been ascertained, it is easy to divide the wages by the number of thousands of hanks produced, so as to find what must be the price per 1,000 hanks to be paid to the spinner.

Here may be seen in what respect the Oldham list differs from a fixed daily wage list. A minder by close and skilful attention to his work, assisted by good spinning and freedom from

breakdowns, may get higher wages than are given in the list, while another minder by negligence, want of skill, bad spinning, or breakdowns, &c., may receive much less wages than are given in the list. This remark, of course, applies with equal force to all other lists.

In actual practice the minder will know what price per 1,000 hanks is to be given, and from this he can easily ascertain his wages. For example, a pair of mules of 86 dozen spindles produce 56,000 hanks of 32's in a week, and the price has been fixed at $13\frac{1}{4}d$. per 1,000 hanks. What will be the total wages?

$$13\frac{1}{4}d. \times 56 = £3 \text{ } 1s. \text{ } 10d.$$

Out of this £3 1s. 10d. the list specifies that the spinner must retain 54·72 per cent., and his piecers the remainder, or 45·28 per cent. This works out to 33s. 10d. for the spinner and 28s. for the piecers.

In calculating the production which a pair of mules is capable of giving off, it is specified that from the full week of $56\frac{1}{2}$ hours there shall be deducted—

(1) $1\frac{1}{2}$ hours per week for accidents and cleaning, with an extra $\frac{1}{4}$ hour for mules above 80 dozen, and if over 100 dozen another additional $\frac{1}{4}$ hour.

(2) For doffing five minutes per occasion for mules of 60 dozen spindles and less, with an extra minute for mules from 60 to 90 dozen, and above 90 dozen another additional minute.

(3) $2\frac{1}{2}$ per cent. for breakages, the same being allowed for in the construction of the indicator.

There are various clauses referring to waste spinning, bobbin carrying, double deckers, turning strings, &c., which run much on the same lines as specified in the Bolton lists.

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